ONTARIO AGRICULTURAL COLLEGE

BULLETIN 124.

# NATURE STUDY

OR

# STORIES IN AGRICULTURE

BY

MEMBERS OF THE STAFF

OF

The Ontario Agricultural College, Guelph.

*PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,*
*Toronto, December, 1902.*

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BULLETIN 124. DECEMBER, 1902

Ontario Agricultural College and Experimental Farm.

# NATURE STUDY.

JAMES MILLS, M.A., LL.D.

Most people look at many things which they do not see, and hear many sounds to which they pay little or no attention. There are, for instance, many intelligent Canadians who have been looking at ash and elm trees all their lives, and they could not describe the bark, leaves, or general appearance of these two kinds of trees, so as to distinguish one from the other. They have also, no doubt, noticed half a dozen or more

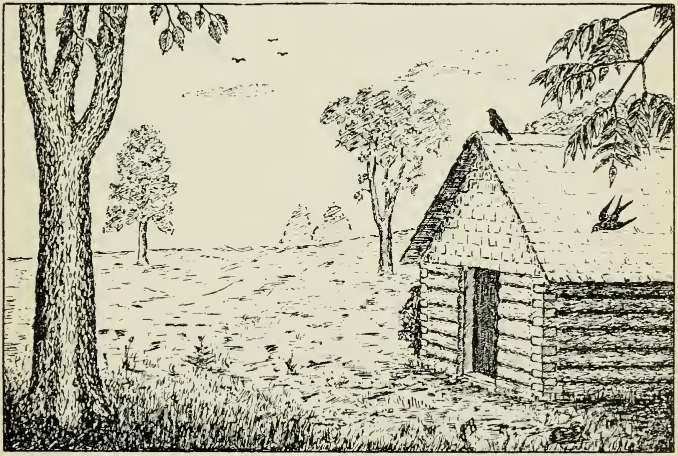


FIG. 1. What birds are these?
What trees are these?

species of birds in their fields or lawns from year to year, and have heard them sing very sweetly, and yet have little or no knowledge of most of them,—their color, markings, songs, or habits.

The aim of nature study is to interest men and women, and especially boys and girls, in the natural objects which they look at, handle, taste, or smell from day to day, in order that they may acquire the habit of observing closely, and so get all the pleasure possible out of their surroundings in life, and find their daily duties less irksome, and gather information that will be helpful to them in overcoming difficulties and in working for a share of the necessaries, comforts, and luxuries of life.

The materials for nature study are everywhere, the soil, the plant, and the animal ; and the judicious study of soils and soil formation, or useful and troublesome plants, or noxious and beneficial insects—first, as objects of beauty or interest in themselves and afterwards as things which are useful or troublesome to man—opens up a field of unending pleasure and profit to the average boy or girl.

The eyes, ears, and other organs of sense in children are wide awake and keenly attentive ; and the one thing needed is nature-loving, well-trained, competent teachers in the Public Schools, to direct and develop the love for natural objects which is so strong from infancy to twelve or fourteen years of age.

One of the best aids—in fact the ever-necessary handmaid—of nature study is drawing. Nothing contributes more to exact and reliable information, say in the study of plants and insects, than an attempt to draw a representation of the object or organ under examination. All parts and the arrangement of parts, with every angle, curve, and peculiarity, must be noticed and represented in some way ; and I regret to say that there is nothing in which our Canadian teachers and schools are more deficient than in this important branch of elementary education. Boys from England are far more proficient in drawing than Canadian boys and girls ; and those who have given any attention to the subject, know what excellent work is being done under this head in some of the leading cities of the United States (say Boston, New York, and Philadelphia), where every teacher, in almost every division from the kindergarten up, teaches drawing. The children at school in these cities are taught to describe by some kind of diagram or drawing nearly everything they look at or read about ; and the results are very satisfactory,—far beyond what one would think possible in a Public School course.

Those who have had experience, almost without exception, say that nature study, properly pursued, does not interfere with ordinary school duties. On the contrary, it breaks the monotony of school routine and increases the interest in the regular school studies to such an extent that the most and best book-work is done where a little time is given every week to the examination and study of some portion of the great world of nature around us.

This Bulletin is, we think, the first formal attempt in the Province of Ontario to present items of information and simple, common-place incidents regarding natural objects, in the hope of interesting some of our young people, and inducing teachers to undertake such work in the Public and High Schools of the Province. These simple stories are, no doubt, very imperfect ; but they constitute a beginning,—the opening up of a very wide and interesting field for observation and study ; and with more time and a careful selection of writers according to their special tastes and aptitudes, we may be able to furnish something nearer what is required in this important department of educational work

# A HANDFUL OF EARTH.

PROFESSOR. J. B. REYNOLDS.

"A handful of earth! Dirt! Surely we are not asked to listen to a story about anything so common as dirt! Dirt sticks to our hands and faces, and we are made to wash it off. It clings to our shoes. It gets onto our clothes, it blows into the house, and makes the furniture dirty, and people have to be continually rubbing and brushing, sweeping, and dusting to get rid of it. We should be very glad never to hear of it again."

Fig. 2. A handful of earth—in its place.

I fancy I hear many boys and girls saying this when they see the title of this story of mine. But stay! I said *Earth*, and what you say is about *Dirt*. Earth is very good *in its place*, but *out of its place*, it is dirt. It is out of its place when it is on your hands or shoes or clothes. Then it annoys you and you call it bad names. There are other things besides earth that sometimes get out of place and are called bad names. I have heard it said that *boys and girls* are all very well in their place, which seems to hint that they are sometimes out of their place. I have known boys, and girls too, make visits to a neighboring orchard. The owner of the orchard was a mean old fellow, and when he saw the children in his orchard he would say, "Plague on those youngsters: They're at it again." And he would send someone, or go himself, to drive them out, just as you would brush the dust off your hands. But the fathers and mothers of those same intruders thought they were pretty good children, and were proud of them. So with this handful of earth. In its place, that is, in the garden or field, it is of untold value.

Earth is so common and unlovely, while "birds and butterflies and flowers" are so bright and beautiful, that all our interest is naturally drawn to these. But we should know that although the soil has no life or beauty in itself, yet it *supports* life, and enables other things to be useful and beautiful.

THE SOIL AND THE ROCK.—Take from the field some fine dry earth. Place a good sized pinch of it on a piece of smooth white paper, and place under this a newspaper or a piece of thick cloth. Tip the whole so as to give it a little slope. Then tap this paper with the finger, and you will begin to see parts of the soil begin to draw away from the other parts. Keep at this, and you will find some of the soil rounding up in little heaps, while the rest scatters over the paper. Roll your pencil forwards and backwards over this last, pressing slightly upon it, and tap again, until no more will round up. Then look closely at the little heaps and the scattered parts. The heaps first formed are made of soil fine as flour. The next lot of heaps have *little grains* like granulated sugar. The part scattered about is sand and lumps. The sand is mostly clear and white, some of the grains sparkling in the sun like diamonds The lumps, perhaps, are made of smaller grains stuck together, and do not look clean-cut and white like the sand. Sand, as you well know, is nothing but small bits of rock. Now, if you hold the little heaps so that the sun shines upon them, you may see, if your eyes are sharp, very small rock-bits among these too. In fact, a large part of all soil is rock. When you come to know geology, you will learn how this rock became broken down into such small bits to make soil. But for the present we are interested in knowing that the soil contains rock-bits of many different sizes.

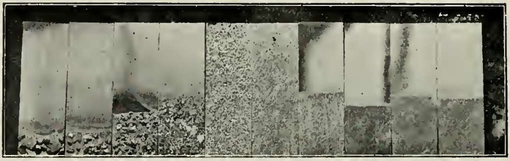


Fig. 3. A soil separated, showing rock grains of many sizes.

Fig. 4. Showing the parts that the trees have given to the soil.

THE SOIL AND THE TREE. "But," you say, "many soils are quite dark in color, while most of this sand is clear and white; There must be something else in soils besides sand grains, or it would not be so dark." Quite true; and now we shall see what this is.

Get from the woods, under last year's leaves, some black mold; and after it has become dried, treat it as you did the sample of earth. You will find much the same separation as before; but on looking closely at the heaps and scattered grains of the mold, you will find two important differences: First, the separate grains, big and little, instead of being white as the sand grains were, are all brown or black. Secondly, instead of looking like rock, these, especially the coarser ones, look like bits of wood.

Long years ago, before the white man came to Canada, even before the red man hunted over these hills and plains, the trees began to grow upon the soil. Year after year, as the trees grew bigger they drew water and food more and more, from the soil. The trees were wise, however, and knew that, although the rain that fell might keep up the supply of water that they needed, yet there was nothing to replace the food they took from the soil, unless they did it themselves. So they agreed to give back to the soil as much food as they took from it. Every year, the maples and the oaks and the beeches dropped their leaves to the ground. Every tree in the forest now and then dropped twigs and broken branches. When a big tree died and decayed, it also fell to the ground, and lay stretched with its arms spreading wide. Slowly but surely all these things—leaves, twigs and trees,—rotted and passed back into the form of mother Earth. And thus the mold, which you find so common in forests, was made.

It is this *vegetable matter*, or humus, that makes soils dark. It is the most valuable and enriching part of the soil, and so nearly all the best soils are dark. The virgin soil of Canada, that is, the soil before it was cultivated or cropped, wore a thick coat of rich brown mold over the sand-grains below. Through many years of plowing and cultivating, these two parts—the humus and the rock—have become mixed together, just as you found in the earth you examined. Wood and leaves are not the only sources of humus. Straw, roots, grass, and clover, if left on the land, will finally become humus.

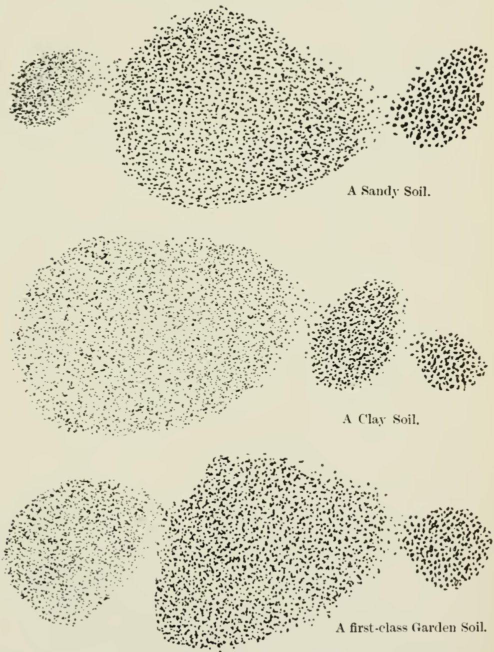


Fig. 5. Showing soils, each separated into fine, medium, and coarse grains.

THE SOIL AND THE RAIN. It was a dry hot summer day. In the fields, the corn and clover leaves hung limp and lifeless. In the gardens, the flowers bent their heads, and had hardly strength enough to put forth their buds. There had been no rain for many days, and the plants had had very little to drink but the dew that gathered on their leaves at night. So they were all very thirsty.

That night the rain fell in a long, heavy shower, upon the fields and gardens. On the steep hillsides it fell, and ran down in torrents to the river below. Upon the gravelly knolls it fell, and trickled quickly down, down, deep into the ground among the gravels and coarse soil-grains, and most of it was soon out of sight and out of reach. It fell, too, upon the clay field, where the soil-grains were all so small and close together that the rain could not find a way between them, and so the rain stood, like little ponds and rivers, in the pits and ruts over the field. Lastly it fell upon good soil, and slowly it soaked away down to the roots of the clover and the corn and the flowers, and down past the roots to a safe storehouse below. Next morning what a change ! Even the crops on the hillside and on the gravelly knolls looked fresh and bright. They had kept enough of the rain for one good drink at any rate. On the clay field, the clover stood in danger of having too much of a good thing, for little patches of water were still to be seen here and there. The good soil seemed almost dry again. The corn leaves had straightened out, and every plant in the field was holding its head up straight and strong.

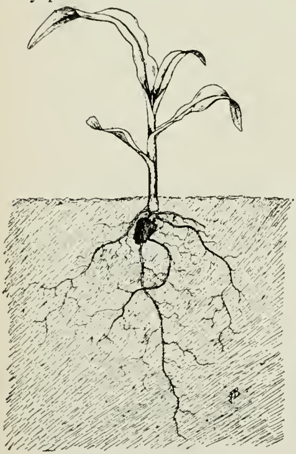


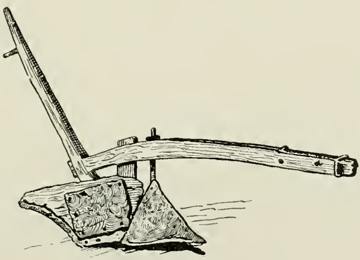
Fig. 6 The Soil and the Seedling.
"The earth all about the roots becomes a scene of life and activity"

A few days later, and again great changes. The hillside and the gravel patch were in as bad plight as ever,— dry and parched. The wet clay soil, in the hot sun, had dried and baked and cracked, squeezing and breaking the tender roots. The heavy rain and the hot sun had done bad things for this soil, and for its litttle nursling plants. But on the good soil, the crops had flourished ever since the rain. As soon as the plant roots and the sun had drunk up the moisture at the surface of the ground, the roots sent to the storehouse below the message for more water. The ready soil-grains below the roots began to hand the water from one to another up through two, three, and four feet, to keep the roots supplied with plenty to drink. And so, while the ground above was dry and dusty, the rain that had fallen into the good soil many days before, was still kept on tap, and handed out from below when called for.

THE SOIL AND THE SEEDLING. In every seed there is a possible plant, which will produce many other seeds, food for man or beast. But before the plant can come to life, the seed must be placed in earth. What sort of earth bed does the seed like best ? Soft, and moist, and warm. Soft, that is, free of lumps, and fine, and mellow, so that the earth may lie snug and close to the seed ; moist, so that the seed may swell and burst, and set the young plant free ; warm, so that the little plant may be nursed into life.

Imagine now, the little seedling just peeping above ground, and sending its thread-like roots down into the soil below. If it is a hard cruel soil, as too many are, it cares nothing for its little nursling, and will very likely let it die. But if it is a kind, good soil, it becomes very fond of the little plant and does all it can to make the nursling thrive. The earth all about the seedling becomes a scene of life and activity. When the plant wants water,—and it is a thirsty little creature,—the sand grains begin to hand the water from one to another till it reaches the little roots. As the water passes by, the humus grains hand out a supply of food and put it into the water. The earth above the roots is all day long drinking in warmth from the sun's rays and handing it down to the roots. When the winds blow and try hard to tear the little plant out, the soil-grains cling hard to the roots and hold them fast in their place. So, you see the soil has all to do with the roots; what it does is out of sight, and therefore, often out of mind. Yet it is well to remember that the usefulness and the beauty of the grass, and shrubs, and trees come in great part from the earth about below their roots.

The flowers, still faithful to the stems,
    Their fellowship renew;
The stems are faithful to the root,
    That worketh out of view;
And to the rock the root adheres
    In every fibre true.—*Wordsworth.*



The wooden plow of the early settler.

# THE STORY OF PLANT ROOTS.

PROFESSOR MELVILLE CUMMING.

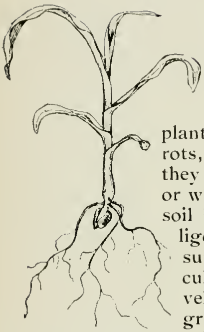


Fig. 7. Corn Seedling, showing leaves, stem, and roots.

Pull up a plant, and you will notice three distinct parts—the leaves, the stem, and roots. The stem and the leaves are the parts above the earth; the roots, the part that is buried in the earth. To the farmer, the roots, being the part in the soil, are in many ways the most important part of the plant. Sometimes he grows such roots as turnips, carrots, and beets for his own use, and then, of course, they are very important; but even when he grows hay or wheat or corn, he can do so only by preparing a good soil in which the roots may grow. With all his intelligence he cannot affect the sunshine and the air which surrounds the stem and leaves; but he can by good cultivation so improve the soil that the roots can develop in the very best way, and by improving the growth of the roots he can improve the growth of the other parts of the plant. Since we are going to study the plant from the farmer's standpoint, we will dig down into the earth and see what we can of the roots of plants.

What are the roots in the ground for? They hold the plant in place. Have you ever walked against a heavy-blowing wind and felt its force, sometimes so strong that you could scarcely stand up? If you have, you can in part imagine the force with which the wind sometimes blows against a tree that is ten or fifteen times as big as you are. The roots of a large oak or maple or pine tree must be very securely fixed in the ground to stand the great strain from such winds; and although most of the plants grown on the farm are very much smaller than trees, yet even they must be very securely held in the soil by their roots.

Not only do roots serve as anchors, but also as the feeding and drinking organs of plants. Plants, as well as animals, must have food and water in order to live and grow; but, unlike animals, they have more than one mouth through which to take in food and drink. By means of their roots they take in all the water they need and all the food which the soil can give them. However, plants do not get all their food from the soil. Part of it they get from the air, and the leaves are the mouths for this food. It will be very interesting, a little further on, to see why these two feeding organs, the leaves and the roots, are so differently formed.

Yet another purpose do roots serve in the life of some plants. As you all know some plants, called annuals, live only one year. Others, called biennials, live two years; and still others, called perennials, live many years. Plants belonging to the last two classes must have some means of storing up food for the winter months. Perennial plants, such as trees and shrubs, generally develop strong stems and branches and store up food in them. But the stems and branches of biennials and some perennials die in the autumn, and these plants store up food for their future use in their roots. Some of these with which you are familiar are the carrot, turnip, beet, parsnip, burdock, blue weed, and dandelion If you pull up any of these in the fall, you will notice that, just next the stem, they have a large thickened root, from which smaller roots branch off. This thickened part of the root is packed full of food to be used by the plant the next spring. Often the farmer takes advantage of such plants and, instead of leaving the roots in the earth for the plant's use next spring, pulls them up in the fall and uses them for himself or for his cattle. Many of you, no doubt, have helped to gather in turnips, carrots, and beets. Some time, when you have a chance, leave a few of these in the ground and see what becomes of them next summer. Before passing on, I will give you a question to think about. Would you take the same means of destroying biennial and perennial weeds as you would of destroying annual weeds? Some common biennial and perennial weeds are burdock, blue weed, chicory, thistles, plantain, and dandelion.

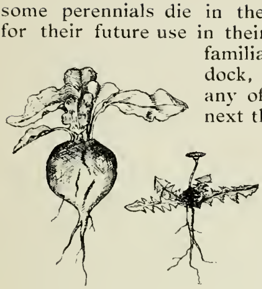


Fig. 8. The roots of the turnip and dandelion.

These, then, are the three uses of roots: 1. To hold the plant in place; 2. To absorb food and water; 3. To act as storehouses of food for the future use of the plant.

Now, there is one thing I must ask you to notice before going any further, and that is, that not all parts of a plant beneath the earth are roots. Some plants have stems growing in the soil; and many people mistake these stems for roots. How many of you, for example, would call the potato a root of the potato plant? It is not, however; and if you will compare a potato with a carrot, which is a true root, you will notice some points in which they differ. You have often noticed the "eyes" of a potato. You will not find any such "eyes" in a carrot. These eyes are buds just the same as, though looking a little different from, the ones you have noticed on the stem and branches of a tree. Besides, if you look very closely, you will find little scale-like leaves just beside the eyes. These, however, soon rub off and you may not be able to see them. And then, if you carefully pull up a potato plant on which the potatoes have begun to form, you will find that the branches on which they are borne are not branches of the root but of the stem, appearing just above, that is, in the axil of a leaf. True roots do not bear these buds or leaves, and they never start in the axil of a leaf. The potato is simply the swollen end of a branch of the stem and is called a tuber. Examine in the same way the Canadian thistle, and couch

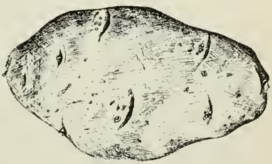


Fig. 9. Showing the eyes of a potato.

or witch grass, and see if all the underground parts of these are roots or if some of them are stems.

You have all tried to pull plants out of the ground ; and in doing so, you have noticed that some pull up quite easily and others with much difficulty. Pull up, for example, a corn plant or an oat plant and then pull up a burdock or a clover plant. Why is it so much easier to pull up the corn or oat plant than the burdock or clover plant ? If you will dig down into the earth you will see that the clover and burdock plants have a long main root extending deep down into the earth, and that other smaller roots branch off from this at different depths and extend out into the earth in all directions, whereas the oat and corn plants have no such main root, having only the smaller roots extending out from the base of the stem. Hence the oat and corn plants are much more shallow-rooted than the clover or burdock. If you will pull up a number of plants you will find some like the corn and others like the burdock or clover, some with very deep and others with very shallow roots. This is one of the many reasons why a good farmer grows different crops and not always the same crops, or, as it is called, follows a "rotation of crops" on the same field from year to year. One year he may grow deep-rooted plants, and these will feed upon the food that is deep down in the earth, and the next year he will grow more shallow-rooted plants, which will feed in another part of the soil; and thus the plants are not so likely to use up all the food from any one part of the soil.

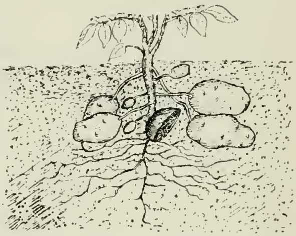


Fig. 10. Showing the tubers arising from the stem and quite distinct from the roots of the potato plant.

This main root, which you noticed in the clover or burdock is called the primary root. The smaller roots growing from the primary root are called secondary roots These in turn may branch, producing third or tertiary roots, and so on until the whole root system of the plant is formed. When the primary root is very much larger than the secondary roots, as we have already seen in the beet, carrot, turnip, and dandelion, it is called the tap root. In the case of the corn or oat plant, you will not have noticed any primary roots. As a matter of fact, if you were

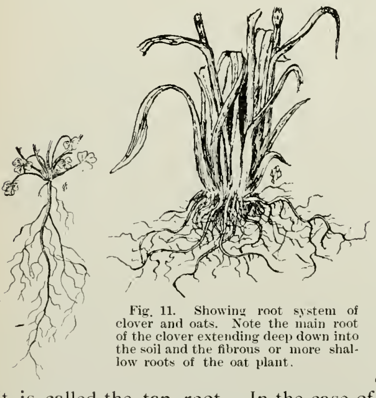


Fig. 11. Showing root system of clover and oats. Note the main root of the clover extending deep down into the soil and the fibrous or more shallow roots of the oat plant.

to notice the very early growth of one of these plants, you would see a primary root which, however, soon disappears and is replaced by secondary roots springing partly from the base of the stem and partly from the lower joints of the stem. These roots are sometimes called adventitious roots.

But not only will you notice differences in the length of roots in different plants, but you will notice differences in the same plants in different soils. Sow some beet seed in a soil that is not deeply loosened up, and notice how much shorter the roots are than those grown from the same kind of seed sown in a deeply-loosened up soil. This shows you why farmers in growing such crops as beets, turnips, and carrots always cultivate and loosen up the soil as deeply as possible.

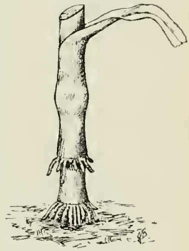


Fig. 12. Showing adventitious roots of corn.

Again, trace out the roots of a plant, such as grass, grown in a soil that remains wet for a long time in the spring, and then do the same with a similar grass plant grown in a soil that dries out earlier in the spring. You will find that the roots of the grass grown in the drier soil, have extended down much more deeply into the earth. The reason for this is, that roots are no fonder of cold water to live in than you are, and therefore in a cold wet soil have to spread out very near the surface. In the drier soil they strike down deeply. Now watch the effect when the dry summer days come. The plant on the soil that was so wet wilts away, because its roots are all near the surface and cannot reach down to the water below, whereas the plant in the drier soil, unless the weather becomes very hot and dry, can grow easily, because its roots are down deep in the soil near the water that lies there. Do you not see from this one reason for underdraining fields?

Once more, trace out for a little way the roots of a grass grown in what farmers call a rich, mellow soil, and then do the same in a soil that is poor in plant food. You will find that the roots in the rich soil have branched very much more than in the poor soil. This is because of the large amount of plant food in the rich soil. Have you ever seen people trying to make a lawn? If you have, you will have noticed that, in some soils, the grasses remain in separate tufts and do not mat into a good sod. These are the poor soils. But in a rich soil you will have noticed that in a very short time, not more than a year or two, a good close sod has formed, on which you can easily play croquet or tennis or other games. This is because the roots have developed so much more thickly in the good soil, and thus have produced a better growth of grass, and have become more closely matted together, making a firmer sod.

Now, we have observed a lot of different things about roots. Let us look a little closer at them and see what we can learn about the way in which they push through the soil, how they hold so firmly to it, and how they absorb water and plant food. You have already discovered how very difficult it is to pull up all the roots of a plant without breaking them. When I tell you that the roots of some clovers have been traced down 30 feet into the earth, and those of some trees 100 feet, you will quickly see that it is not very likely that you have ever seen all the roots of a plant. So if you would know all you could about them, you should grow some plants in your own rooms. Take some bean, pea, radish, or other seeds and place them between folds of moistened black cloth or flannel. Be sure to keep the cloth moist. In a few days the seed will have germinated and the stem and roots will each be an inch or two long. Now notice that, about a quarter of an inch from the tip the root is covered with a fringe of delicate whitish hairs. So delicate are they that if you touch them you will destroy them. These are known as root hairs and they are the feeding organs of roots. It is very difficult to see them in a plant pulled out of the soil, because they have been destroyed by the pulling out. However, if by the greatest care, you can pull out a plant without destroying them you will find these little root hairs near the tips or new parts of all the roots. As the roots grow, the root hairs keep falling off the older parts and new ones grow on the newer parts. Hence you will see that it is at the ends of their roots that plants take in food and water from the soil, and that the older parts merely serve to carry these up to the stem. How many of you have ever watered trees growing on your lawn or in the garden, and in doing so have poured the water just close to the trunk or stem of the tree where the old parts of the roots grow? If you have, do not forget the lesson you have just learned; and the next time you water trees, pour the water a little further away from the stem or the trunk, so that it may quickly soak in to where the tips of the roots are growing.

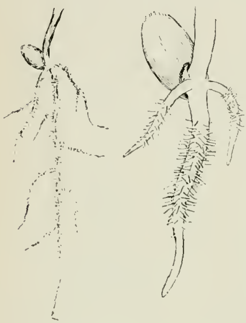


Fig. 13. Showing root hairs on seedling of a bean plant. (a) natural appearance; (b) some magnified.

Take one of the little bean plants when the root is about ¾ of an inch long, and make small marks upon the root about 1/16 of an inch apart with a pen dipped in India ink. Wrap the bean in damp cotton wool, allowing the marked root to be free. Fill a small bottle with water and place over its mouth a piece ofcard board with a hole in it. Hang the bean plant through this hole leaving the root free in the water. Allow it to grow in a dark place two or three days. Take it out and notice the position of the marks on the roots. You will find that the marks near the tip are now at unequal and greater distances apart, whereas those farther back are little changed in position. This shows you that the region of growth is near the tip of the root. This is of great importance in the root growth of plants, because it gives the roots the power to push their way in and out among the particles of the soil,

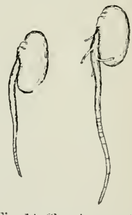


Fig. 14. Showing at (a) the marks on the root of the bean plant. (b) The same marks after 2 days, thus showing the region of growth.

even into the most difficult places. You have noticed that roots are very pliable—easily bent or twisted; in fact, not unlike threador cord. If the region of growth were some distance back from the tip, the root would have the same trouble pushing its way through the soil that you would have if you were to try to thread a small needle by holding the thread two or three inches back from the end. I may also tell you, because you cannot see it without a strong microscope, that each root tip has a sort of cap or cushion of cells which protects the true living part of the root in its act of pushing in and out among the particles of soil. Thus, you see, the little roots by being so pliable, by having their growing regions so near the tip, and by having these protecting caps, are well fitted for growing in the soil. If you carefully lift a young wheat or other plant from the dry earth, you will notice that each rootlet is coated with particles of soil. These stick closely to the root, and it takes much shaking, and even washing, to remove all of them. Thus you see how closely roots, by means of their fibrous branches and root hairs, come into contact with the particles of the soil in which they grow, and hence they have every chance to get all the food the soil can give them, and, besides, become so securely fastened in place that it is almost impossible to pull some plants out of the earth. You remember that in the very first part of our story we wondered why roots should be so different from leaves, which are also feeding organs of plants. You see now that if roots were shaped like leaves they could never hold so closely to the particles of the soil.

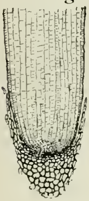


Fig. 15. Showing the protecting cap of a root.

Roots are certainly wonderfully adapted to their life in the soil, and, although there are many other interesting things you might learn about them, yet I think you have learned enough this time to make you take a greater interest in even such things as roots ; and, I hope also, to make you take a greater interest in the way in which farmers prepare the soil for the roots to grow in.

Fig. 16. A young seedling wheat plant pulled out of dry earth to show how intimately the roots come in contact with the particles of soil.

# THE STORY OF A GRAIN OF WHEAT.

C. A. Zavitz, B.S.A.

A grain of wheat is very small. It is much smaller than the smallest clay marble that I ever made or that I ever saw. In fact it is so small that a little ant is able to carry it from one place to another. Boys and girls greatly enjoy making clay marbles. They can become very much interested also in trying to make grains of wheat out of clay and water. Even with the greatest of care and the best of success, however, only artificial grains of wheat can be made in this way. No person, either

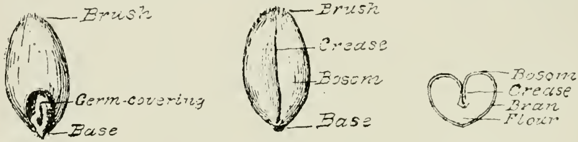
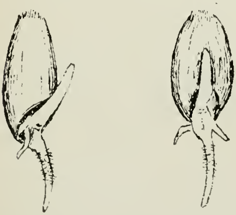



Fig. 17. Back view. Front view. Cross section.

young or old, can make a real grain of wheat; yet a real wheat grain is of much greater value and is of far greater interest for the boys and the girls to examine and to study than even the prettiest artificial grain of wheat which was ever made. Allow me to tell you a few of the many interesting things about a genuine living grain of wheat.

An average grain of wheat is about one-quarter of an inch in length, and one-half as wide as it is long. The hairy end is known as the brush and the opposite end is usually called the base. Along the front side is a well defined crease or furrow extending the entire length of the grain. This crease should be narrow and not very deep. The portion on either side of the crease is called the bosom, which should be large, plump, and rather smooth. The backs of some grains are curved and those of others are actually humped Most grains have a slightly wavy appearance along the central part of the back, but some are so plump that the wavy appearance is scarcely noticeable. There is still another part to be mentioned, and that is the rough portion near the base and at the back of the grain. This is the covering to the embryo, or germ, or seed proper. The embryo itself can be readily examined if you first soak the grain of wheat in water for about a day, and then carefully remove this covering. A grain of wheat is made up of three principal parts,—the bran, or skin ; the endosperm, or flour ; and the embryo, or germ. The grain should be plump, the skin thin and nearly smooth, and the germ fairly prominent.



Side view. Back view.

Fig. 18. Grain of wheat sprouting, four days in ground.

The great difference between a grain of wheat and a marble of clay lies in the fact that the former has life, and the latter has no life. Nothing can be done to induce a marble to grow. This is not so with a grain of wheat. As long as it is kept in a dry condition, it is simply sleeping. When it is placed in the ground at the right season of the year and surrounded with the proper amount of moisture, heat, and air, it soon awakens. A great change takes place in a very short time. The grain

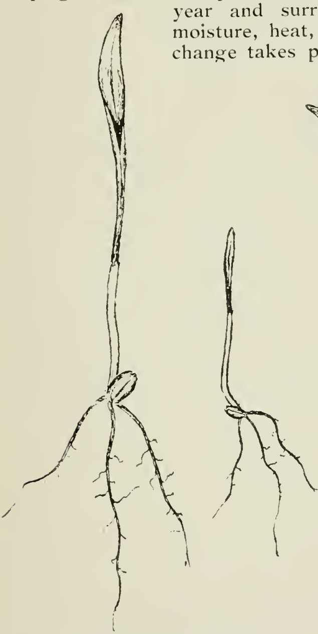


Fig. 19. Plants produced from grains of wheat of different sizes, nine days after planting.

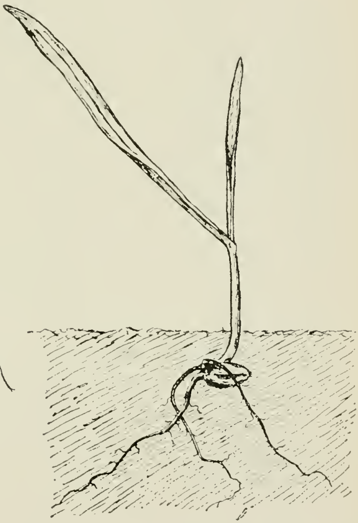


Fig. 20. Young plant of wheat, thirteen days after planting.

absorbs water, the embryo swells and begins to grow, and in a few days a young plant is produced.

The little plant at first obtains its food from the starchy part of the grain. As soon, however, as it sends its roots into the soil and its leaves into the air, it obtains its food from outside sources. The little, fibrous roots get food from the soil in the form of liquids, and the green leaves get food from the air in the form of gases. With the proper conditions, the plant makes a wonderful growth ; and, as time passes, we observe the formation of several long, slender, upright stems, with a very interesting and peculiarly arranged head on the top of each.

An average head of wheat is about three and a half inches in length. It is made up of a large number of spikelets which are arranged alternately along the stalk. Each spikelet usually contains three flowers. The flower is small and is enclosed by two glumes, which afterwards form the chaff. These glumes are sometimes blunt and sometimes elongated into awns or beards. The very interesting little flower, therefore, cannot be seen except by opening up the glumes, which

Fig. 22. Spikelet of wheat. Wheat flower.

can be readily done by means of a sharp knife or a pin. A small magnifying glass will greatly help in examining the various parts of the flower. The flower produces the seed which at first is very small, but which grows rapidly and ripens in three or four weeks after the formation of the flower.

Front view. Side view.

Fig. 21. Head of wheat, natural size.

As the grain ripens, the leaves turn brown and wither, the stems or straws change to a green or lightish yellow color, and the glumes become dry and harsh. From the one seed which was planted, we have obtained a well ripened plant, which is ready to be cut, harvested, and threshed, and will furnish us with straw, chaff, and grain, all of which are useful.

I have touched on only a few of the points in connection with the life history of the wheat. The germination of the seed; the feeding of the plant; the growth of the leaf, the stem, and the head; the arrangement of the flower; the production of the grain,—are all subjects which are very interesting and worthy of a person's close attention and careful study.

Fig. 23. A head of wheat divided into three parts: (a) the grains; (b) the chaff, and (c) the centre stem.

In view of the importance of the wheat crop, a large amount of experimental work has been done at the Ontario Agricultural College in order to glean information which may be of value in increasing both the yield and the quality of the wheat of Ontario. The results of these experiments have been published in bulletins which have been distributed among the farmers from time to time. Upwards of 300 varieties of wheat have been grown side by side on the College plots. These varieties possess many variations, and may be classified according to the time of sowing, as fall and spring; according to the structure of the chaff, as bearded and bald; according to the composition of the grain, as hard and soft; and according to the color of the grain, as red and white. There are other classifications also, but the ones here mentioned are the most common. Certain varieties of wheat are particularly well adapted for special purposes; some for the production of bread, others for macaroni, and still others for pastry, biscuits, breakfast foods, etc. For making flour, both the red wheats and the white wheats are used; but for the other three purposes, the white wheats are used almost entirely.

For the very best results in crop production, a selection of the most desirable plants from a field of the best variety of wheat should be made. From the grain obtained from these plants, none but the fully-developed, well matured, plump, sound grains should be used for sowing, with the object of producing grain of high quality to be used for seed in the following year.

As we grasp the meaning of the little verse

> "Little drops of water,
> Little grains of sand,
> Make the mighty ocean
> And the beauteous land,"

we can better realize how it is that the little grains of wheat make up the world's production or about two and a half billion bushels, or of Ontario's production of about twenty-five million bushels annually.

Let no one despise the little grain of wheat, but rather let everyone give honour where honour is due, and gladly acknowledge its high position in the vegetable world.

# THE STORY OF A LOAF OF BREAD.

Professor Robert Harcourt.

Every one has seen and handled a grain of wheat. Each little grain is a store-house filled as full as it can be. In each of these little store-houses is everything that is needed to make our bodies grow. Some parts are useful in making bone, some in forming flesh, and some in forming fat, while others are useful in keeping up the heat of the body, and in giving us power to walk and run. Each grain of wheat contains everything that is necessary for all these different purposes. This is one reason why wheat is worth so much money and why we grow so much of it. The people over in England do not grow enough wheat for their own use ; so we grow some for them and send it across the ocean in big shiploads

While we use a large amount of wheat, we do not like to eat it until it has been ground and made into flour. Long ago, when people first began to grind wheat, they crushed it between any two flat stones that happened to be near at hand. A little latter they kept two flat stones specially for the purpose, one of which was fixed in the ground while the other was turned on it Methods of grinding in pioneer days are illustrated in Fig. 30. When treadmills, windmills, and, later, water-wheels came into use, the grinding was done at mills by men who understood how it should be done. But in all these ways of grinding, all the different parts of the wheat were left together in the flour. Later, the millers found a method of sifting out the coarser parts.

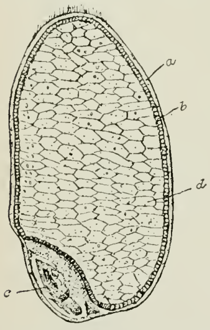



Fig. 24. Longitudinal section of wheat grain. (a) outer coverings; (b) aleurone cells ; (c) germ ; d Endosperm, the part of the wheat from which the flour is made.

The grinding of the grain and the sifting of the flour have gradually been improved, until to-day we have mills covering acres of ground, and making thousands of barrels of flour each day. In these mills, they are able to separate the different parts of the wheat, and can make ever so many different grades of flour.

You naturally ask : What is the difference between their various grades of flour ? Are they not all made from the same wheat ? Yes, they are ; but to understand the difference, we shall have to learn something about the different parts of a wheat grain. If we cut a wheat grain through from end to end, and place it, properly prepared, under a microscope, which is a wonderful instrument that makes things look larger than they really are, we shall see something like that shown in Fig. 24. If we were to cut the wheat crosswise, it would appear as in Fig. 25.

Around the outside of the grain, as you see in the picture, there are several thin coverings. Underneath these, there is a row of cells tightly packed together, called the *aleurone* cells. These outer layers and the row of cells taken together form the greater part of the bran. The little egg-shaped part at the bottom of the first picture is the germ from which the sprout starts when the grain commences to grow. The remainder of the grain, known as the *Endosperm*, is made up largely of starch and gluten. From a miller's standpoint, this part of the grain is by far the

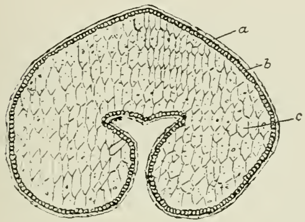
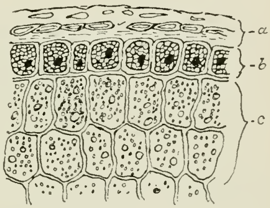



Fig. 25. Cross section of a grain of wheat: (a) outer coverings; (b) Aleurone cells; (c) Endosperm, the part of the wheat from which the flour is made.




A part of the section more highly magnified

most important; for the object of milling is to separate the endosperm from the rest of the grain and grind it to flour.

In the roller-process mills of to-day, the wheat usually passes through six pairs of rollers before the grinding is completed. In the first, the miller seeks just to break the grain into pieces. After sifting, the coarse parts, called the "tailings", are passed on to the next pair of rollers, where they are flattened, and some of the floury substance ground off of them. This is also sifted, and the tailings passed on to the next rollers where the flour is removed. After the wheat has passed through all the rollers in this way, the flattened pieces are almost entirely free from flour, and are classed as bran. Figure 26 is a picture of a piece or "*scale*" *of bran*. In all such methods of grinding wheat, the centre part is rubbed off first; and, being free from bran particles, it makes very white flour. This forms the grade of flour known as "patent." That got by grinding closer to the bran is known as the "baker's" grades. Still closer grinding forms the low grades of flour. Generally speaking, the more bran particles there are in the flour, the lower it is graded. The outer part of the wheat, nearly all of which goes into the bran, contains much more bone making material than the flour. Because of this, some say that the "patent" and "baker's" grades of flour are not so good as the flour made by the old stone process. The Graham flour is supposed to be all of the

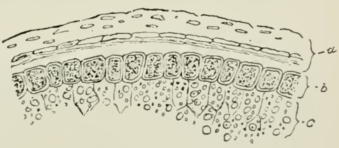



Fig. 26. A cross section of a piece of bran: (a) outer covering of the wheat; (b) aleurone cells; (c) endosperm. Notice that the endosperm has not been all ground off from the bran.

wheat ground into flour ; but it is hard to grind the bran so fine that it will not have a bad effect on man's digestive system. To overcome this, there has been invented a machine which peels off the outer coat of the wheat grain. The remainder is ground, and is known as "entire wheat flour." Such flour is always dark in color, because the gem is ground with it ; but it contains more bone and fat producing material than flour made in any other way.

It is very difficult to determine the exact quality of a flour ; but there are certain general rules by which a good bread flour may be judged quickly. It should be white with a faint yellow tinge, and it should fall loosely apart in the hand after being pressed. When put between the teeth, it should "crunch" a little ; or when rubbed between the fingers, it should be slightly gritty. As flour is prepared, possibly there is no one point which determines its quality so much as the amount of gluten it co ntains. Some one asks : "What is gluten?" Have you ever made


3 2 1

Fig. 27.—Loaves of bread made from equal weights of flour : 1. From Manitoba wheat ; 2. From Wild Goose wheat ; 3. From Michigan Amber wheat.

gum by chewing wheat? Nearly all children in the country have. The gummy part is gluten. If you have ever tried to make gum from oats, barley, or corn, you have failed ; because these grains do not contain gluten. It is because wheat contains this substance that it is so much used for bread-making. If you take a little flour and add enough water to make it into a stiff dough, and allow it to stand for an hour, and then take it between your fingers and knead it in water, you will see the water get white with the starch that is separating from the dough. Continue the washing until the starch is all removed. What remains is gluten. Notice how tough and elastic it is.

Some varieties of wheat contain more gluten than others. There is also a great difference in the quality of glutens : some are tough and can be pulled out like a piece of rubber ; others are soft and break when pulled. The wheat which contains the most gluten of a good, tough elastic quality, will make the best flour for bread-making. For this reason, what are known as Spring Wheats are usually better than those known as Fall Wheats. To illustrate this point, flour was made from three kinds of wheat—Michigan Amber, one of our best winter varieties ; Wild Goose, a very hard Spring variety ; and Manitoba, No. 1, hard. These flours were made into bread and a loaf of each lot was photographed. The same weight of flour was used for each loaf. Fig. 27 shows the difference in size of the loaves. Manitoba flour made the largest loaf, because it contained more and better gluten than the others. Millers call a flour which contains good gluten, "strong," and one that contains poor gluten, "weak."

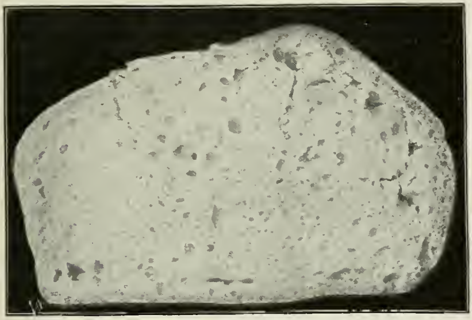


Fig. 28.—Loaf of bread made from normal flour from which part of the gluten had been removed. Note the big cracks up through the loaf, from which the gases escaped without causing the dough to rise.

Now that we have learned something about flour, let us see if we can learn something about the changes that take place when it is made into bread. If you have ever tried to wet flour with water, you will have noticed how hard it is to get the flour all wet. That is because the flour is so very fine. One of the main objects of making the flour into bread before it is eaten is to separate these fine particles, so that the digestive fluids of the stomach may more easily mix with them. The baker commences by mixing the flour with water. He also puts in yeast, or something which will produce the same effects, and mixes it all together so thoroughly that the water and yeast come into contact with each little particle of flour. When the paste, or dough, containing yeast, is set in a warm place, the yeast begins to "work," as we say, and the dough to "rise." The yeast causes changes, one of the principal results of which is the production of a gas. This gas, in trying to force its way through the dough, comes into contact with the tough elastic gluten which spreads out and holds the gas in so as to form little bubbles, and thus causes the dough to rise. In

Fig. 29.—Loaf of bread made from normal flour.

this way, the fine particles of flour are separated from one another. The tougher and more elastic the gluten, the better the dough will rise, and the lighter the bread will be. This is where good gluten is valuable.

Take a slice of bread and examine it carefully. Notice the little openings or holes in it. These little holes were formed by the gas being held in by the gluten as just described. If too much yeast is added to the flour, too much gas will form, and the openings will be very large, or the gas may even spread out the gluten so far that the walls of the bubbles will break. If the gluten is all or partly removed from the flour, the dough will not rise, because there is nothing to keep the gas in, and we shall have a loaf like that shown in Fig. 28 and 29.

After the yeast has worked enough, the dough is put into a hot oven. Here the heat kills the yeast and causes the gas to expand and stretch out the walls of the little bubbles, or pockets, which it formed between the particles of dough, and changes some of the water into steam, thus raising the loaf still more. The heat on the outside of the loaf converts some of the starch into *dextrin*, a gummy substance with a sweetish taste. This is why the crust is sweeter and tougher than the centre of the loaf. The harder the loaf is baked, the darker the color, through the changing of some of this dextrin into caramel, which is a form of sugar. Some bakers moisten the top of the loaf with water, or water containing a little sugar, to develop caramel, and to give the loaf a darker and richer color. Both dextrin and caramel are soluble in water ; and, therefore, they are easily digested. This explains why the crust of bread and toast are sweeter than the soft interior of the loaf, and also why they are more easily digested.

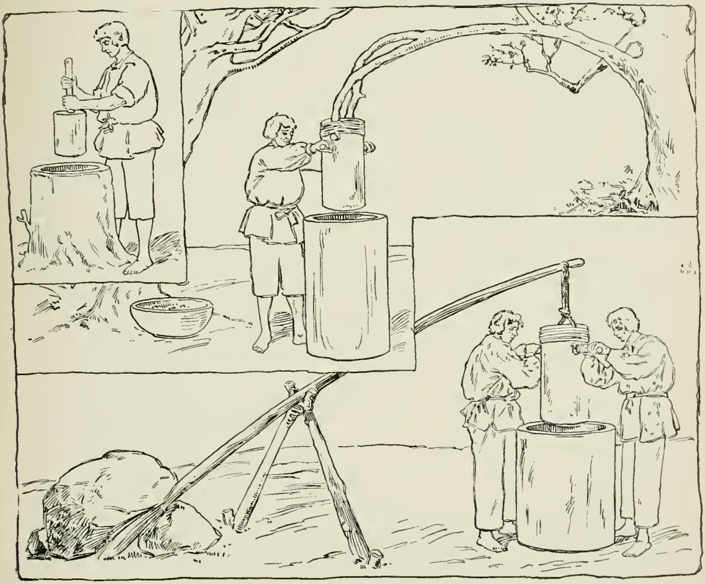


Fig. 30, In Pioneer days.

## THE STORY OF THE YEAST PLANT.

Professor F. C. Harrison.

We have all heard of yeast, but perhaps, not very many know that yeast is a plant—a very different plant, however, from what we usually see. It has no stems, no leaves, and no roots; it is not even green; it is so small that a single plant cannot be seen by the naked eye. In order to see it, we must use a powerful magnifying instrument, called a microscope. If we examined a yeast plant by means of a microscope, we should see that full grown plants were round, oval, or egg-shaped, and so small that 5,000 of them placed end to end would be about an inch long. Figures 31 and 32 will give some idea of the shape of this plant, and convey a hint as to its size, as the illustrations are photographs of yeast plants magnified 1000 times.

Most of us eat bread every day; but only few of us stop to think that we are indebted to the yeast plant in a large measure for the flavour and digestibility of the "Staff of Life." The baker kneads, or mixes, his flour, water, and yeast and then leaves it in a warm place, which favours the growth of the yeast. In a very short time, the yeast begins to grow by feeding upon the sugar in the flour, and in so doing changes the sugar into alcohol and a gas, commonly called carbonic acid gas, which is familiar to us all in ginger ale and other aerated drinks.

The gas formed from the decomposition of the sugar by the yeast plant in the dough, is unable to get out, owing to the sticky nature of the kneaded flour It is held in small bubbles, the form of which can be seen on looking at a piece of bread, the small holes being the spaces which are made by the gas bubbles in the dough. The heat in the oven acting upon these bubbles causes them to expand, or grow large, and thus pushes the particles of flour apart, so that the loaf when baked is much larger than the piece of dough before baking.

The alcohol, a liquid formed, as stated above, by the yeast plant acting upon the sugar in the flour, may be smelt, if an opening is made in the dough when it has risen; but most of this substance is evaporated, or driven away, by the heat in baking, and only a very little of it is retained in the bread.

Thus we see that by the action of the yeast the particles of flour are divided and subdivided, giving a large surface for the digestive fluids to act upon when the bread is eaten; and for this reason, bread is more digestible than cakes made with baking powder or sour milk and soda.

The use of yeast for making bread is very old. We know that the Jews were acquainted with the use of "leaven," or yeast; for we read that Lot "did make them a feast and did bake unleavened bread."

And the use of yeast for making wine is even more ancient; for we learn that Noah, the second father of mankind, planted a vineyard and made wine.

The Chinese also knew of the use of yeast for bread and wine making; for about the year 2000 B.C. Ching Noung, a Chinese philosopher, taught the Chinese the art ot husbandry, and the method of making bread from wheat, and wine from rice.

In the process of wine making, the grapes, as soon as they are picked, are carried to a suitable vessel and there pressed. The juice of the grape, called "must," together with the skins, is then placed in a large vat; and the yeasts, which are always present on the surface of ripe fruit, begin to grow, and in their growth produce alcohol and gas. This production of alcohol is called the first fermentation; and when it is nearly over, the wine passes through a strainer into a cask to undergo the second fermentation. This cask fermentation lasts for several months, and during this time flavouring substances are formed which give the aroma, or *bouquet*, to the wine. The high price of certain wines is due to the excellency of their aroma, which is largely a product of the yeast-plant.

Sometimes injurious forms of yeast get into wine, and cause wine diseases. One of the commonest is a yeast-like plant which changes the alcohol into vinegar, and gives the wine a sour, or vinegar, taste.

Cider and perry may be regarded as the wines of those districts in which the grape does not flourish. Cider is the juice of the apple fermented with yeasts that are naturally present on the surface of the fruit, and perry is the fermented juice of the pear.

Barley, yeast, and hops are used in the making of beer. The barley is allowed to germinate, or sprout, in order to change the starch of the kernel of the barley into sugar. This material, extracted by means of hot water, is the food in which the yeast plant grows and produces alcohol and carbonic acid gas.

Fig 31. Full grown yeast plants greatly magnified, the natural size being only one-thousandth-part of the size shown in the figure.

Other substances are used to give flavor to the beer; but the essential part of the making is the changing of the sugar solution into alcohol by means of the yeast plant.

Special varieties of yeasts are used to make different kinds of beer, as ale, lager beer, etc.; and, as in the case of wine, disease-producing yeasts very often appear and produce a cloudy, or turbid, liquor, which is disliked by those who use such drinks.

From a study ot the changes in bread, wine, etc., we see that the yeast plant, in order to grow, requires a proper supply of food, which should consist of a mixture of nitrogenous substances, a certain amount of carbon (usually supplied in the form of sugar), and also mineral matter. About 20 per cent. of water is also necessary, and a suitable temperature, between 60 and 90 degrees Fahrenheit. If these conditions are present, the yeast-plant is able to live, grow, and produce other yeast-plants.

The yeast plant consists of a single cell, which, at a certain stage, sends out a bud from some part of its surface, which gradually increases in size This bud may or may not remain attached to the parent stem. If it does so, and the old stem continues to send out more buds, a mass of cells is soon formed ; but, if each cell as it grows produces a bud, a long chain of cells is formed.

Under certain conditions (moist surface, plenty of air, favorable temperature, and strong cells), small round bodies from two to eight in number are formed inside the old cell, which are called *spores*. These may remain dormant (that is quiet or asleep) for a considerable length of time, but will germinate when placed in suitable food. They are usually more resistant than the cells in the growing condition. Even the

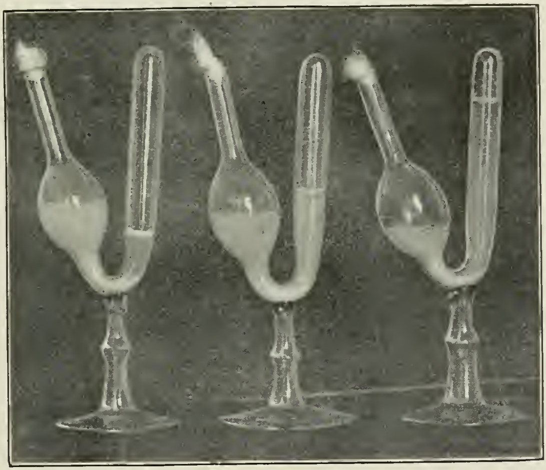
Fig. 32. A wine yeast, showing spore formation,—magnification, 1 000 diameters. From 2 to 4 spores may be seen in most of the cells.

ordinary cell lives for a considerable length of time when it is kept dry ; and the dry yeast cakes, which are sold for bread-making purposes consist of dried yeast cells mixed with starch or ground corn.

There are several hundred varieties of the yeast plant, possessing different properties, as there are many varieties of apples ; and as some kinds of fruit are better than other kinds, so some varieties of yeast are more suitable for use than others.

Yeasts of different varieties are used in the manufacture of liquors, such as beer, whisky, wine, cider, etc., and any of these yeasts could be used in bread making ; but some would require twelve to fourteen hours to raise the dough to the same extent as another would in seven or eight hours. Figure 33 shows that some varieties of yeast produce more gas than others. Thus, the variety in number 1 tube would be more valuable for a baker than the one in number 3 tube, because it produces more gas ; but this variety would not be suitable for other purposes,—say for the manufacture of wine.

In the same way, a yeast used for the making of champagne would not be suitable for making beer ; and such is the influence of the yeast on the flavour of the product, that very good imitations of certain wines may be made by growing in apple juice the yeast taken from the wine.



1 2 3

Fig. 33, Fermentation tubes containing flour and water—
1. With addition of a distillery yeast.
2. " " brewery yeast.
3. " " dried cake yeast.
Note, in the right arms of the tubes, that there is more gas in 1 than in the others, showing the more energetic working of the distillery yeast. For the same reason, there is more gas in 2 than in 3.

The injurious yeasts are also quite numerous. Besides those we have already spoken of, we might mention those that produce bitterness, not only in wine, but occasionally in milk and cheese. These yeasts grow in milk, feeding upon the milk sugar, changing it into other compounds, and giving rise to an unpleasant bitter taste, which affects, not only the milk, but the cheese made from it.

# THE STORY OF A POUND OF BUTTER.

PROFESSOR H. H. DEAN.

Mrs. Boss and her neighbors agreed to hold meetings throughout the winter, when not busy. They also decided to discuss buttermaking at the first meeting, and this is what a man who understands cow talk heard them saying :

MEETING No. 1. The first to speak was Mrs. Brindle. She said that it was her candid opinion that all his talk about "pedigrees" and "butter-blood" did not amount to very much. She thought that if her owner would look around he could find, among her friends plenty of good cows for making butter, which had not any papers to show their breeding. For her part, she considered that blood was of no account. What she wanted was a cow that could *do* something.

Fig. 34. Holstein.

Mrs. Black - and - White, known in higher cow circles by the name of Mrs. Holstein-Friesian, or Mrs. Holstein for short, said she considered that it was better to give a large flow of milk, so as to have plenty of skim-milk for the calves and pigs, as well as what is used for buttermaking.

Some of the other cows thought that there was too much to handle to get a pound of butter from such milk. Mrs. Canadian said that some poor farmers could not raise enough feed to satisfy the appetite of the previous speaker, and she believed that a small cow. which is a small eater, is best for a poor man.

Fig. 35. Shorthorn.

Mrs. Shorthorn, who also belongs to the high class in cow society, argued in favor of the cow that gives milk to drink, and butter to eat ; and if not satisfied with that, her owner could turn her into beef. Some of the members remarked that combined machines never work so well as special ones.

Mrs. Ayrshire said that, as the discussion was on butter-making, she had little to say, though some of her relations were just as good for butter as any cows.

Miss Jersey and Miss Guernsey both spoke at once, and stated most positively that milk rich in fat could be most profitably turned into butter. Such milk made butter with the golden color, and the firm texture in hot weather. They also said that it did not cost the owner so much for the feed to make a pound of butter, and pointed to "official tests" to prove their statements.

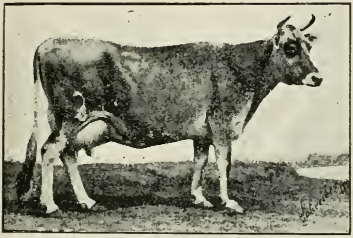


Fig. 36.—Jersey.

At this point the other cows began chewing their cuds so vigorously that it was thought advisable to adjourn the meeting.

No. 2. At the next meeting, it was resolved to discuss "feeding for butter," and the only speaker on this occassion was Old Mrs. Lineback, who had many years of experience "browsing" and running around straw-stacks in winter, and eating in fence corners and along dusty road-sides in summer. She had also tried these new-fangled feeds, called silage, gluten meal, cottonseed meal, and the like, but her experience was that there was nothing equal to good, sweet June grass for making butter. When the grass is short and somewhat dry, she advised feeding green peas and oats, or a small quantity of sweet silage, together with bran and oats. In winter, clover hay, sweet silage, mangels, bran, oats, and peas make excellent foods for producing butter. She would also emphasize the importance of plenty of pure water and salt as aids to digestion, and necessary for a good flow of milk.

With these statements, all agreed, and there was no further discussion.

No. 3. – The third meeting was a sort of "indignation meeting." The chief speakers on this occasion were Miss Jersey and Miss Guernsey. They both protested against being awakened from a pleasant nap at half-past four on a winter morning. So far as they were concerned, they did not see any reason for their owner waking his wife and children from a sound sleep at that hour, then tramping to the stable with a lantern, whose bright light hurt their eyes very much, and *they were sure it was spoiling their beauty*. They would much prefer having their owner not awaken them before daylight, as they did not believe it wise to be eating in the dark when they could not see what was going into their mouths. The quantity

Fig. 37.—Guernsey.

of milk in their udders never hurt them, if it was a little longer time between night's and morning's milking. They had also observed that whenever the Hired Man had to attend to them and do the milking at five o'clock in the morning, he was usually in a bad temper. He pinched their teats, and sometimes hit them with the stool, which made them feel cross and they did not give so much milk, nor did they put so much fat into it. Mrs. Holstein and Mrs. Ayrshire said, in their case if they were not milked at regular hours and the same number of hours apart, that the milk in their udders hurt them, and they would enter a strong protest against the views expressed by the previous speakers. When, however, they gave less than two gallons of milk a day, they said it did not make so much difference to them about milking exactly the same number of hours apart

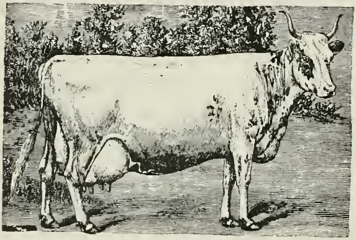


FIG. 38.—Ayrshire.

Mrs. Tidy-Cow said she would like to make a very strong complaint against being milked in stables where the air was foul, where she could not keep herself clean, and against owners who made no effort to improve the cow-houses in winter. She had found that it was better for the person, when milking, to wipe the udder and teats with a clean, damp cloth, before commencing to milk, and to milk with dry hands especially in winter. She believed in milking quickly, milking out clean, and kind treatment at all times, especially while milking, as this caused the cow to give more milk.

Mrs. Cow-Curious would like to see a milk-sheet, scale, and test-bottle in every stable, so that she could see what her neighbors were doing.

All agreed that it would be excellent, if each one could know how much milk and butter her neighbors gave in a year. Now that their curiosity was aroused, it was resolved to find out how their milk was made into butter ; and, if at all possible, they would go into their owner's dairy, and watch operations.

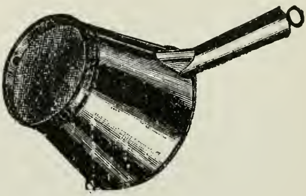


FIG. 39.—Cream Strainer.

No. 4.—The next meeting was held in Mrs. Busy's dairy, soon after milking As there were no chairs suitable for the guests, each one stood on the floor of the dairy, being careful not to get in the way. It was also agreed that they talk very little during the visit to the dairy, but keep their eyes open and see what was done with the milk which was to be made into butter.

They observed that the first thing which Mrs. Busy did was to strain the milk through two or three thicknesses of cheese cloth and a fine wire strainer, to remove any dirt that might be in the milk.

Some of Mrs. Busy's customers, it was explained to the visitors, liked butter made from cream set in shallow pans, some liked it made from cream raised on deep cans set in ice water, and some would have nothing but separator butter. So all three methods were in use. Mrs. Boss and her neighbors noticed that the milk from Miss Jersey, Miss Guernsey, and Mrs. Canadian were set in shallow pans and deep cans, because the milk from these contained fat in the form of good-sized globules (balls) which rise readily. The milk from the others was all run through the separator, which is a machine with a bowl that revolves very fast, producing centrifugal (flying from the centre) force. The heavier skim-milk is forced to the outside of the bowl, and the lighter cream comes towards the centre. The sweet warm skim-milk is fed to calves and pigs, and the cream is put in a can to ripen (sour), after being cooled to 65 degrees. The visitors noticed that some sour milk (culture) of good flavor was added to the cream, which was for the purpose of producing good flavor in the butter, especially in winter. The cream was then put into a moderately warm place until next day, when it would be ripe and ready to churn.

In the meantime, their owner's daughter, Miss Busy, had washed the separator and the milk pails, and everything was in nice order for the day.

After apologizing for the tracks made on the floor of the dairy, Mrs. Boss and her neighbors went back to the stable, having learned a great deal.

As they were leaving the dairy, Mrs. Ayrshire became excited and switched her tail into the cream can, for which breach of good manners Miss Jersey and Miss Guernsey gave her a very severe look which almost made her horns turn down.

No. 5.—As soon as the morning work was done at the farm house, the churning completed and the butter from the separator cream was ready for market, Mrs. Busy went to the cow-house to finish her explanations ; because, as she said, she never could churn and get the butter ready to go to market in time when she had a lot of visitors. Besides, visitors were a nuisance in the dairy, for they were always in the road and were poking their noses into everything.

She began by saying that the milk set in shallow pans must be kept *cool*, and be set in a clean dry cellar, or milk-house, where no bad flavors can get into the cream. In twenty-four hours in summer, and thirty-six to forty-eight in winter, the pans are ready to cream (skim). This is done by running a thin-bladed knife around the edge of the pan to loosen the cream. (Mrs. Line-Back said she had always seen this done with a finger. Mrs. Busy explained that this was not a very clean way to loosen the cream, and that a knife was much better ) The cream is then held back with the knife to allow some skim-milk to moisten the edge of the pan, which prevents the cream sticking to the tin. The cream is then guided into the cream-can with as little skim-milk as possible.

(At this point, Mrs. Brindle interrupted to say that she had always heard of a strainer skimmer being used for taking cream from pans, but she could see now that it caused a waste of the cream and was not good practice. "We are always learning!"). The shallow pan cream is then set in a cool place until there is sufficient for a churning, when it is brought near the stove to ripen (sour) for twenty-four hours.

Cream on deep cans (Creamers) may be removed from either the top or the bottom of the cans. The milk should be set for 12 to 24 hours in summer, and 24 to 36 in winter for the cream to rise on milk set in deep cans. Mrs. Busy also explained that it is necessary to cool the milk as rapidly as possible to 40 degrees, or not more than 45 degrees as soon as convenient after milking, by using ice in the water. And, by the way, she said that every person who makes butter should use, not their finger, but a good glass thermometer to find the temperature. The cream is kept in a cool place; and, when there is enough for a churning, it is warmed and ripened in the same way as cream from shallow pans.

Fig. 40. Thermometer.

The ripening (or souring) of cream is a very important point, as this largely decides the flavor of the butter. The ripening is caused by very small plants (called bacteria) which grow in the cream. It is important to have the right kind of bacteria seed to put into the cream, so as to get proper plants and proper flavor.

Good seed may be bought, or it may drop into the cream from the air. It is best to buy the seed in pure form at first, then grow the plants in pure skim-milk. Add some of this to the cream at each churning, but keep some to put into fresh skim-milk each time. This you must know is the great secret of nice flavor in butter.

(Mrs Brindle said to her neighbor that she did not take much stock in the "seed" business. She had observed that at most of the places where she had been, the farmer's wife just let the cream take "pot-luck," and most of the time the butter could be eaten; and, if it couldn't, her owner could always trade it at the store for crackers and tobacco.)

Mrs. Busy did not take much notice of this talk of Mrs. Brindle's but went on to explain how to tell when cream is ripe. She said: Use your eyes, and see if it is thick, glossy, and velvety in appearance; use your tongue, and if it tastes slightly sour, it is ripe. Use your nose, and, if it smells pleasant, it is ready to churn.

Churn rich separator cream at a temperature of about 50° to 52° in summer, and 52° to 56° in winter. Cream from cans and pans should be from four to eight degrees warmer than separator cream as a rule.

We must leave the talk about churning until next day, as I hear Tommy calling for his mother.

No. 6.—Quietness reigned in the stable next day when Mrs. Busy continued her story of a pound of butter:

The best churn is a simple box or barrel, which is easily kept clean. These new style air-churns and churns with patent dashers are no improvement. First, scald the churn to fill the pores of the wood with water, to prevent cream and butter sticking to it, and then cool with cold water. The cream should be strained through a coarse strainer into the churn to prevent "specks" in the butter. If coloring is used, put it into the cream at this stage. Close the lid firmly and turn the churn at the rate of 60 or 70 turns per minute. Allow the gas to escape through the opening at the bottom of a barrel or box churn for a few times during the first ten minutes. Continue churning until the butter is the size of wheat-grains; then draw the buttermilk off through a strainer.

(Mrs. Boss remarked to a neighbor that she had always seen the butter churned into a lump, or until the dasher would stand on top of the butter, before taking the butter out of the buttermilk in the old dash churn.)

When the butter will not "come," said their Instructor, it is chiefly because the temperature or heat is not right. Cream which is difficult to churn will nearly always "come" after warming to 70° or 74° and churning for half an hour.

After the churning is done, add as much water at a temperature of 45° to 50° in summer, and 55° to 60° in winter, as there was cream at the beginning. Then revolve the churn rapidly for about two minutes and draw off the water. Allow the butter to drain for 10 to 15 minutes; then add fine butter salt at the rate of about one ounce of salt to a pound of butter in the churn; or remove the butter to a lever worker and add the salt. Work the butter gently with a downward pressure, until it is free from moisture on the outside, until it is close in appearance, and until the salt is all dissolved. I wish, said Mrs. Busy, to impress upon you the importance of preparing the butter for market in a neat and attractive manner. Use a wooden printer to mould the butter into oblong prints, weighing one full pound, or a little over, then wrap them in parchment paper, having the name of the dairy neatly printed on the wrapper. Put the butter in a cold place, and send to market once a week in a neat shipping box. In summer, use ice in the shipping box to keep the butter firm. Always send the butter to market with the best looking and neatest person on the farm. *Send none but the finest butter to regular customers, and be very careful of your reputation,* were the last words of the teacher.

No. 7.- To-day we shall try to learn what it is that makes good butter, said Mrs. Busy in her last talk. *Flavor* is the most important thing in good butter. Cream which is kept too long (more than three or four days) before churning makes butter which has an "old" flavor. The food which a cow eats also affects the flavor of the butter. Turnips, brewer's grains, decayed silage, and some weeds always taint butter. Butter with good flavor should have a pleasant, sweet taste and smell, and should make the person eating it wish for more.

The next point is the grain, or texture, which should not be too hard, nor yet too soft or greasy, or salvy. Butter should spread nicely on bread, and then it is nearly perfect in texture. The color should be even —free from "mottles," white waves, or streaks. Streaks in butter are caused by improper working. It should not be too yellow, nor yet too white for home markets.

The amount of salt in butter should be according to the taste ; but it must all be dissolved, and the butter must not be "gritty." This grittiness is caused by using too much salt or by using coarse salt.

The package should be neat, attractive, and stylish, so as to please the eye of the customer.

Such butter will be eaten much more readily than poor butter ; and we wish people to eat as much as possible, you know, said Mrs. Busy.

Clean, sweet butter is one of the most easily digested fatty foods, and all persons should have plenty of good butter on their tables.

This finishes our lesson on a pound of butter, and I hope that you now know something about how butter is made, and that you will take more interest in your business of making milk for butter.

Mrs. Boss and all her friends bawled their thanks of appreciation for the instruction given All were of the opinion that if owners of cows would take more interest in them, talk to them as friends, share their secrets with them, and give them more encouragement, as well as more to eat, cows would give more milk, which would make more butter, which would bring more money, which would enable boys and girls to have a greater number of nice things in the home on the farm.

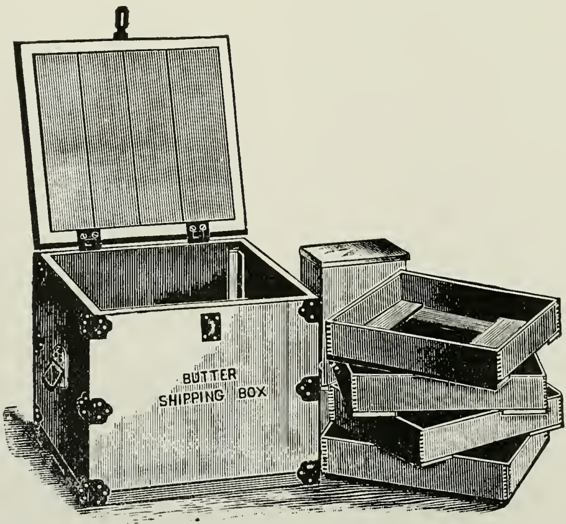
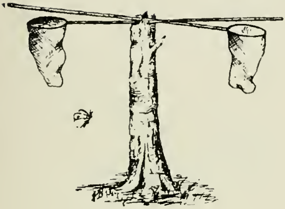



Fig. 41.—Shipping Box for Butter.

# THE STORY OF THE CABBAGE BUTTERFLY.

PROFESSOR W. LOCHHEAD.



THE White Cabbage Butterflies can be seen almost any fine day in summer flitting about the cabbages in the garden, and among the wayside flowers. Although harmless, they are not liked by farmers and gardeners, because they are the parents of the common green "worms" which do much harm to cabbages by eating holes in their leaves.

It seems strange that a green, crawling cabbage worm should grow into a dainty, white-winged butterfly ; and it is the object of this story to tell, in a simple way, the strange life of this insect. It must be remembered, however, that the life stories of all insects are not alike. Some insects spend their whole life above ground ; some partly below ground and partly above ; some almost altogether in water ; some partly in the water and partly in the air ; some eat their food while others suck up their food as a liquid; some spend part of their life as a crawling caterpillar, while others have no such stage. So varied are the habits of insects that a noted writer once said :— "Insects walk, run, and jump with the quadrupeds, fly with the birds, glide with the serpents, and swim with the fish."

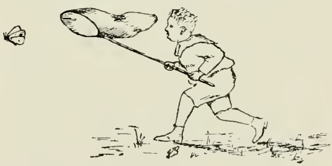


Fig. 42—The boy and the insect.

It would be interesting work to find examples of many of the insects to which this writer referred, and to study their habits ; but this story must deal with the White Cabbage Butterfly.

Fig. 43—Egyptian Mummy in its case.

The ancient Egyptians had a strange custom of embalming their dead, and wrapping them in linen bandages. These mummies, as they are called, were placed in curiously wrought cases, and stored carefully away in secret tombs or pits, in the belief that after a time life would return to them.

Now we have creatures which nature changes into *living mummies* for five or six months in the year ; and living mummies ought to be more interesting than dead ones. These may be seen at any time during the winter if a little search be made for them under fence-rails, under the eaves of outbuildings, and in other sheltered places. I mean the pupae, or resting forms, of insects. But the particular mummies to which I shall refer are the chrysalids (Fig. 44) of the White

Cabbage Butterfly, which are usually abundant in late autumn on fences about cabbage gardens and turnip fields If one of these chrysalids be examined, it will be seen how carefully the tongue, feelers, and legs are folded over the breast and tightly packed together within its "mummy" case.

But of all the chrysalids which are alive in the fall, only a few are living in the spring. For many years observers have noted this fact, and my custom has been to prove it for myself every spring My walk this March afternoon was back along the farm lane, where I have always found chrysalids in early spring. I knew exactly where to look for them, for I had watched the full-grown caterpillars, or "worms," last autumn leave the cabbage, turnip, and rape plants upon which they had been feeding, crawl up the posts of the wire fence to the underside of the capping board, and change to mummy-like chrysalids, each securely fastened to the board by a silken pad at its hind end, and by a slender silken band about its middle. I found some of the chrysalids where I had seen them last fall ; but a few of these had been killed by the grubs of little four-winged flies that had stealthily placed eggs within the chrysalids before winter set in. The greater number had been snatched away during the winter by birds who had found out their hiding places.

Fig. 44—A Cabbage Butterfly Mummy or Chrysalis slung up to a rail.

If one of these chrysalids is brought into a room in early spring, it will not be long before another wonderful change takes place. It will first show slight signs of movement, then its skin will crack open along the back, and soon a white butterfly will come out. At first its body will be soft and weak, and its wings small and shriveled ; but in a few hours the body will become firm, and the wings will be filled out and expanded, ready for flight. As soon as the March snows have melted, many of the white butterflies may be seen flying about, lured by the bright sunshine into leaving their comfortable winter-quarters for

Fig. 45.—Cabbage Butterfly. (a) Male, at rest, wings erect ; (b) female.

the warm breezes of early spring. But if cold weather returns again many a poor butterfly is frozen to death. Those that have been made only stiff with cold, the sun's hot rays bring back to life again.

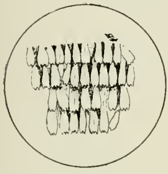


Fig. 46.—Scales on the wing of the Cabbage Butterfly. They overlap like shingles on a roof.

The nature student will observe that all the white Cabbage Butterflies are not marked exactly alike. Some have two black spots just below the middle of each fore-wing, while others have only one. The former are the females, and the latter the males (Fig. 45.) They all have six legs, and four wings covered with very small scales, which brush off readily. Under a microscope these scales can be seen to have the shape and arrangement shown in Fig. 46.

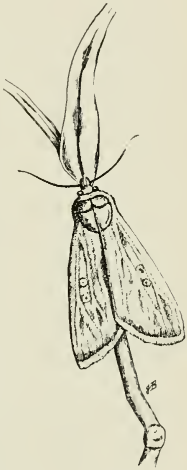


Fig. 47.—An Army-worm Moth at rest, showing the simple feelers, how the wings are folded.

But there are scale-winged insects which are not butterflies; for example, the large army of moths, big and little, which are readily attracted to lights during the late summer months. We can, however, easily tell butterflies from moths in these ways: The wings of butterflies at rest are held erect, while those of moths are folded closely over the back or by the sides; the feelers, or antennæ, of the butterflies are always knobbed at the tip, while those of moths are either simple or feathery; and butterflies fly about during the day, while moths as a rule fly at night or in the dusk. (Fig. 47.)

Like most butterflies, the white Cabbage Butterflies are fond of sipping the honey of flowers; but, unlike many, they show no decided liking for any special color or plant. Some observers are of the opinion that they perhaps visit yellowish-white flowers most frequently, but of this fact we are not absolutely certain. It is always interesting to creep up to a butterfly which is sipping nectar from a flower, and watch it uncoil its long sucking tube and insert it into the corolla. The honey is sucked up through the tube by means of little muscles acting

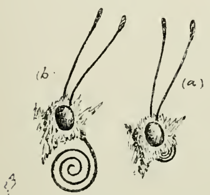



Fig. 48.—Head of Cabbage Butterfly, showing the sucking tubes coiled in (a) and partly uncoiled in (b).

Fig. 49—The eggs of the Cabbage Butterfly.

on a bulb at its base, just as water is drawn up from a cup into the mouth through a straw. (Fig. 48).

The female Cabbage Butterflies begin laying their pale-yellow eggs about the middle of April on the leaves of Shepherd's Purse, Mustard, and other like plants that have already come up. These eggs are beautiful objects, flask-shaped and ribbed crosswise as well as up and down. We must, however, examine them under a microscope, if we wish to see their extremely delicate beauty. Usually several eggs are laid on the under surface of the leaves in an erect position, but seldom are they in clusters. (Fig. 49).

In about a week tiny green "worms," or caterpillars, hatch from the eggs and begin to nibble at the leaves provided for them by the instinct of the mother butterfly. They eat greedily, and "gorge themselves till they seem near bursting." As a result, their growth is rapid; but as the outer skin cannot stretch enough to allow for the increase in size, the caterpillar must at certain times form a new skin under the old one and throw off the latter. This *moulting*, as it is called, occurs four times in the life of the caterpillar, before it changes into a chrysalis.

How different these caterpillars look from the white butterflies! They have horny biting jaws which work sideways, and eight pairs of legs—not all alike, however, for the last five pairs are more like stubs than legs. Their feelers can scarcely be seen, and wings are altogether wanting. Their bodies are long, and are plainly made up of thirteen segments, or rings.

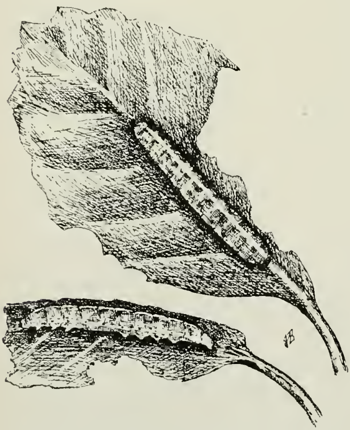


Fig. 50. Two full grown cabbage worms resting after a good meal.

Reference has already been made to the change from the caterpillar to the chrysalis. The first summer chrysalis stage lasts about twelve days, and a second brood of butterflies appears about the end of June. Eggs are again laid, from which a second brood of caterpillars makes its appearance and feeds on the leaves of cabbages and other allied plants during part of July and August. These change into the second summer chrysalids, from which in twelve days the third brood of butterflies comes out in September. Eggs are again laid, and from these hatch the caterpillars which are usually so abundant in late autumn. These change into the chrysalids which pass the winter under fence-rails and other places.

Quite often in autumn many cabbage-worms appear bloated and sickly. They are sluggish and have no desire to eat. If some of the worms be put into a box and taken home, where they can be easily watched, the cause of the sickness will soon be made out. Small white maggots bore their way out through the skin and settle upon the poor caterpillar, as in Fig. 51; and if these maggots are watched, it will be found that they soon begin to spin silken cocoons about their bodies. The caterpillar has sometimes enough life left to crawl away from its tormentors an inch or two; but usually it dies beside them, and in a day or two no trace of its body can be found. If these cocoons be placed in a box for a few days, small four-winged flies will come out through lid-like openings at the end. These flies are *parasites*. By means of a needle on the hinder end of their body, they pierce the skin of the cabbage worm and lay their eggs within its body; in a short time the eggs hatch small maggots, which grow and feed within the body of their host until they become full grown, when they come out as already described.

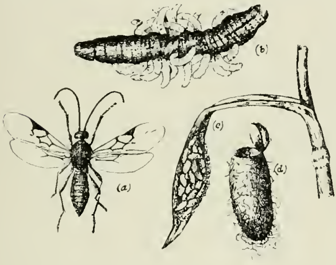


Fig. 51. (a) The 4-winged fly which lays her eggs within cabbage-worms; (b) the maggots coming out of cabbage-worm to spin their cocoons; (c) a mass of cocoons; (d) cocoon enlarged showing how the fly comes out by raising a lid.

Frequently, too, some of the chrysalids, which we find in early spring, are dead and straw-colored. When one is broken open, many little, grayish maggots may be seen to fill up the entire space within; and, if the dead chrysalids are kept in a closed box for a short time, many little bronze-colored flies make their appearance. These flies also are parasites. Their eggs are always laid within the chrysalis case late in the fall, and the maggots which hatch from the eggs feed on the body of the chrysalid. In a short time they are full-grown, and fill up the space occupied by the body.


Fig. 52. The Insect and the Boy.

One other thing about this insect may be noted. Its breathing system is made up of tubes which branch through the body and supply air to the colorless blood The openings of the tubes, or breathing pores, can be readily seen with the naked eye along each side of the body in the same line as the yellowish dots (Fig. 50.)

A good practical way of killing cabbage-worms, when they are spoiling the cabbages, is to dust a mixture of one pound of insect powder and five pounds of flour through a cheesecloth bag upon the infested plants. The fine powder of the mixture fills the breathing pores, so that the air cannot get into the interior of the body, and the worm is suffocated

How strange and eventful is the life of this butterfly! *Strange*, because, beginning life as a beautiful egg, which is easily broken, it soon becomes a sixteen-legged worm-like creature, which, after growing and moulting, reaches a certain size ; then it changes into a passive body resembling an Egyptian mummy ; which after remaining in this state for a definite time, bursts its case, and comes out a dainty, white, four-winged insect, flitting hither and thither among the flowers and sipping their sweets. *Eventful*, because it is ever exposed to danger from the attacks of parasitic insects, birds, and other animals, including man himself, and from the changing conditions of heat and cold, rain, and snow.


Fig. 53. The story of a cabbage-butterfly for a year. There are three broods or generations.

# THE STORY OF THE BEES.

H. R. Rowsome.

Almost every one has, on some drowsy midsummer day, stood before a hive of bees, as close as he dare, and watched with absorbing interest the small portion of their daily toil he was able to see going on around the hive entrance, and has wondered what operations were carried on within that busy community.

If the hive is of a comparatively modern form—one with movable combs set within wooden frames - it is an easy and safe matter to open the hive, take out the combs, and watch its inmates by the hour. Bees do not know one person from another, except as one learns their whims in order to deal with them peaceably ; they are annoyed by persons standing in *front* of a hive and interfering with their flight to the hive. It is not well to wear wooly or black clothes when among bees, because the hereditary antipathy of bees to the bear is aroused if they catch their hooked feet in wooly clothes or hairy wrists ; bears, on their part, keep up their traditions by destroying many telegraph poles in searching for bees' nests, on account of the humming of the wires.

Place a veil of leno over your head, get a bee-keeper's smoker, and puff a few whiffs of smoke in at the entrance to the hive. This drives the sentinels, who are looking for robber bees, into the hive ; gently lift up the cover and blow half a dozen puffs over the tops of the frames. The smoke causes the bees to go down into the hive ; each one dips head first into a cell and fills herself with honey and is then as good natured as a man after a full dinner. Now with a screw-driver pry a frame loose and lift it out. On a warm day all the combs may be taken out and leaned against the hive. One should be careful not to make rapid movements as if inviting a fight, and should avoid crushing the bees or jarring the hive.

One will first notice that it is at the top of the combs that the honey is placed. This is for the sake of convenience in feeding the brood below, just as in a stable, the hay is stored in the loft. Honey, as such, does not exist in flowers but is really *made* by the bees. The bee has a very long under lip of reddish color, which can very readily be seen when in use ; and with this she laps up the nectar that is contained in flowers. This nectar passes into a sort of crop and there undergoes a chemical change, which gives it certain medicinal qualities that make it curative of colds. This is honey. The bee gathers a load of twice its own weight. One can easily notice how a loaded bee drops heavily upon the alighting board, almost with a thud, or, missing it, falls into the grass before the hive and pants and struggles for half an hour to reach the hive. Each bee fills one cell at a time The honey, as it is carried into the hive, is nine-tenths water, most of which has to be removed or the honey will sour. The bees accomplish this, especially at night when they cannot work in the field, by standing in rows before the entrance of the hive ; and there, in rank after rank all along the bottom board and up on the combs, their heads all pointed towards the interior, with abdomens thrust upwards and feet firmly planted, they go through the motion of flying without stirring from the spot. This forces a strong current of air through the hive, which absorbs the moisture in the honey and carries it outside of the hive. The work is very exhausting, and they work in short relays or shifts. In this way, if a colony has gathered a hundred pounds of honey in a season, it has also expelled from the hive one or two barrels of water. By this means too, the hive is ventilated and kept cool in very warm weather; but if the entrance is so very small that but little air can be forced in, the bees become discouraged and turn to loafing. The bee is not always an example of industry.

When nectar cannot be obtained bees will suck juice out of fruit. Raspberry juice will show through the bee's abdomen and give it a bright red appearance. Sometimes they gather a very rank liquid from the surface of leaves and grass. It looks like dew, and is called honey-dew. It falls upon the ground, being sprayed into the air by a louse or aphis, —the cow of the ant.

Looking at the comb again, you will notice that just below the honey there are many cells filled with a red or yellow substance. This is pollen, often called bee-bread, because it tastes not unlike bread. We used to believe that the bright yellow balls on the hind legs of the bee were wax. This is not the case; it is pollen, or the dust of the anthers of flowers. It is collected by hairs on the pollen brushes of the legs; then kneaded into a ball and placed in the pollen basket, a spoon-like hollow with stiff hairs on one side, like stakes on a wood-rack. One can watch this operation very closely by placing, early in spring when there is no pollen, a dish of oat meal thirty yards or so from the hive, with a little honey in it to attract bees there Bees sting only in the immediate neighborhood of their hive. Sometimes when the pollen is very plentiful, as in cucumber blossoms, they roll their bodies in it and pick it off with their feet. Each bee visits only one kind of flower on each excursion and thus the flowers visited are cross-fertilized without being hybridized. Another product that is carried in this way is bee-glue. It is used to stop up cracks in the hive to keep out draughts It is that sticky substance on poplar and horse chestnut buds. Below the pollen is the greater part of the comb which is nearly black and contains the brood or young bees in all stages of growth.

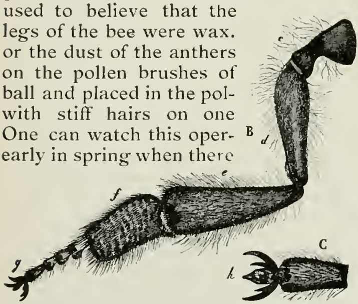


Fig. 54.—B, Hind leg of worker; *e*, tibia hollowed on outer side as pollen-basket; *f*, tarsus with pollen-brushes; *g*, foot, with claws, side view; C, foot, front view, more enlarged. [From nature.]

The most important personage in the hive is the queen or mother-bee, — so-called because she is the mother of all the bees in the colony. She is shy and hard to find, but easily recognized, being nearly twice the size of a worker. Early in spring when food commences to be brought in—for the queen is provident and will not lay when the larder is empty—she begins to deposit eggs, one at the base of each cell, and slightly glues it there. If she happens to place two or more eggs in a cell, the workers, that is the bees that sting, remove all but one to other cells. Drone, or male, eggs are placed in the larger cells and workers or female eggs in the smaller cells. She lays eggs of either sex at will; and the workers can distinguish the sex of an egg by some unknown instinct. At the end of three or four days, the eggs hatch into small, white maggots. The nursing bees prepare a

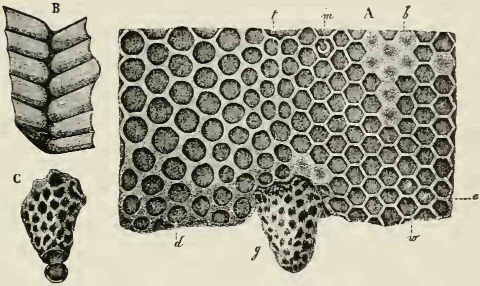



FIG. 55.—A, Comb. front view: *d*, drone-cells; *w*, worker-cells; *t*, transitional cells used for storing honey and bee-bread; *g*, queen's cell; *b*, brood capped over; *e*. eggs; *m*, larva or maggot. B, Section of sheet of comb, showing inclination of cell. C, Queen-cell, with cap cut off by workers. [From nature.]

food of honey, pollen, and water, partially digest it after the manner of patented foods for infants, and pour it into the cells for the grubs. In from four to six days, the maggot grows almost large enough to fill the cell. The nurses then seal over the apartment with a porous lid of wax and the grub enters the pupa state. From the middle part of the under lip two silky threads issue, which cling together and form a single thread; continually extending and retracting its body, it spins a silky white cocoon, something like that of the silk-worm. The inmate of the cell is now transformed into the shape of a bee, but is pure white, and for that reason is called a nymph. In twenty-one days or so after the egg is laid, the young bee chews away the cap of the cell. If you examine a comb of sealed brood, you will generally see two or three of them with their heads half way out of the cells, taking a first view of the world. When they emerge they are weak, flaccid, half grown creatures, covered with silver grey hairs that give them such a new appearance as to excite in the beholder the liveliest sympathy. The nurse bees then clean out the cell and fasten down its silken lining which serves to strengthen the comb, and is so thin that a hundred of them scarcely diminish the size of the cell. The first day the young bee does little but crawl about and sip honey; then in its turn it becomes a nurse and feeds the maggots. When about ten days old, along with scores of other young bees, it plays during the warm part of the day, just before the entrance to the hive. It is a pretty sight to see them dancing in the warm sunshine and learning the use of their wings; in half an hour they go into the hive again and all is quiet. Besides being nurses they are tidy little housekeepers, removing every impurity and all dead bees. At two weeks, the young bee builds comb and goes for its first load of pollen, of which it is as proud as a boy is of his first pair of trousers. After this it undertakes to gather nectar. After from two to four weeks of this labor, it dies from the wear and tear of life. This generally happens out in the field, when, under a full load of honey, it is too feeble to reach home ; or its career may be cut short by the toad that lives under the hive, or by the kingbird, or its feet may be stuck fast in the gummy pollen of the milkweed. But in winter and spring they live eight or nine months.

The drone or male eggs are laid in cells a third larger than the worker cells and, when capped over, are much longer. The drones are bulky and have the proportions and habits of the alderman of tradition. They fly about in the middle of the day to sharpen their appetites, and when in the hive, do little but gobble and sip honey. They can neither sting nor collect food. However, when food does not come in rapidly, they are bundled out of the hive ; often a wing is torn off and they are given a hint to go. This happens every fall and, at that time, the drones will be found all by themselves on the outside combs, hiding from their termagant sisters, after the manner of men in house-cleaning time. When expelled, they are often found in some warm place like a hot-house.

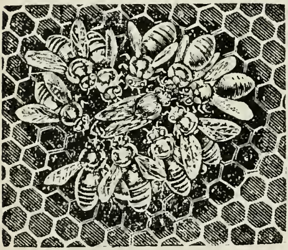


Fig. 56.--The queen and her retinue.

The queen, curiously enough, is hatched from a worker egg, and is often developed from a worker maggot. When bees wish to rear a new queen, they choose three adjacent worker cells, cut out the partition walls, and throw them into one. The cell is turned downward and looks very much like a peanut. Two of the worker maggots are destroyed and the third is supplied with about half a thimblefull of very strong food, called royal jelly. The worker grub, two or three days old, is to be changed into a queen. Sometimes when worker eggs or maggots cannot be found, bees will, without giving up hope, try to rear one from a drone grub, which, however, dies from the strong food. Two days feeding on this food, alters her color, curves her sting, doubles her size, deprives her of wax pockets, lengthens her life to three or four years, and reverses all her instincts. When she leaves the cell in which she has lain head downwards, she takes a sip from an uncapped cell ; and then runs around and stretches her legs. She hunts for other queen cells of which there are about a dozen. If the workers permit her, she tears a hole in the side of the cell and stings the inmates because queens will not tolerate a rival. If another queen is found they fight, the workers standing around, and not interfering. Queens very often are afraid to leave their cells ; and in that case they pipe—making a plaintive cry, a sort of " peep, peep," that may be heard several yards from the hive.

If nectar and pollen are coming in in large quantities, the queen will sometimes lay two or three thousand eggs a day, producing during her lifetime between a million and a million and a half. The hive, of course, becomes overstocked by the amazing fertility of the queen ;

and steps are taken towards sending out a colony. Queen cells are begun and a week before the first queen comes out, by a sort of preconcerted mutual agreement, the inmates of the hive divide into two parties, one remaining in the hive and the other, which consists of the old queen and about three quarters of the colony, starts out to seek fortune elsewhere. Besides the old queen, the swarm is composed of many young bees, some of whom fall upon the ground too feeble to fly, drones, and a number of veterans whose tattered wings and hairless bodies show that they have seen something of life. The departing queen soon settles on the branch of a tree or other convenient spot and the whole swarm collects in one solid mass around her. While the swarm hangs there, scouts are sent out to look for a suitable home, and a hollow tree in the woods is generally chosen. In Asia Minor, a treeless country, swarms were sometimes found in the stomachs of dead beasts, as in the case of the lion killed by Samson ; and from this arose the superstition* that decaying flesh could of itself produce a colony of bees. The scouts return and report, for one bee may often be seen talking with another by crossing its horns, or antennae, with its own. The cluster of bees breaks up and follow the scouts. Even in these days some try to make a swarm cluster by tanning or beating tin cans. This is a survival of a heathen ceremony. The worship of the goddess Cybele, who taught mankind agriculture, was enthusiastic. Her priests ran about with dreadful cries and howling, beating on timbrels, clashing cymbals, sounding pipes, and cutting their flesh with knives. There is another tradition. If there has been a death in the family, the bees will take offence and die during winter, if they are not informed of the event.

Bees had a government and a civilization when we were savages. The division of labor was understood ; laws of hygiene were practiced ; and provision for the rainy day was made, when our ancestors obtained their daily bread by turning over stones in the pools of the sea shore, looking for crabs and clams.

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* Compare the legends of Aristæus the first bee-keeper.

# THE STORY OF THE BIRDS.

PROFESSOR M. W. DOHERTY.

Fig. 57. Swallows migrating.

THE snow has gone, the grass is growing green again, the buds are swelling in the trees, the leaves begin to open - Spring has come ; and, in a few days, we may expect to see our feathered friends again. They have been paying a visit to the people of the South, and, having travelled in foreign places and seen strange sights, they will greet us on their return with a merry tale set to sweetest music.

Many kinds of birds spend the summer with us, and in autumn go southward to spend the winter months. Others come to us from the northern districts and remain here over winter, returning in the spring to the place whence they came. There are other birds that spend the winter season south of us and the summer season to the north of us, so that in their migratory flight, they simply pass through our district on the way to and from their breeding places. These are " passing migrants" A few remain with us summer and winter. Who has not heard the peculiar " quank, quank" of the White-breasted Nuthatch coming from the almost lifeless snow-clad woods. In spring and summer these same birds may be seen running up and down and around the trunk and limbs of the trees. As climbers, the Nuthatches excel. They can run rapidly

Fig. 58. The Cuckoo migrating.

down the trunk of a tree headforemost. Woodpeckers even do not attempt this feat In the southern part of the Province, the Crow remains all winter ; and so, along with the Nuthatch, must be classed as a " resident."

The migratory flight of birds is a most interesting study, and has engaged the attention of bird-lovers for centuries. A great deal, however, is not yet understood regarding the " lines of flight." For instance, " The Eastern and Western Movement of the Blue-bird" in our Province remains unexplained.

What causes these migratory flights ? You immediately answer : " The change in temperature." This answer is partially correct, but you are leaving out of consideration a very important factor, viz., *food* *supply*. This, coupled with inherited memory, probably more than anything else, controls the migration of birds. Do all birds migrate in the same

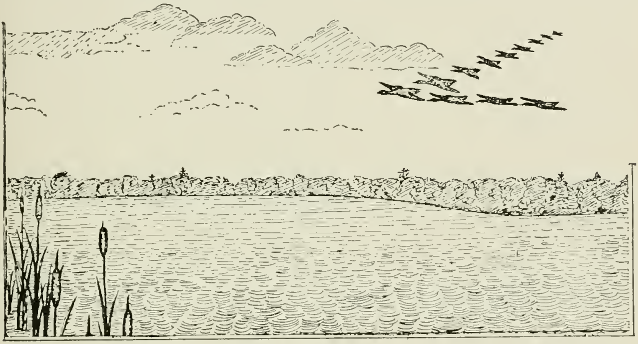


Fig. 59. The flight of the ducks.

manner? No. We have all seen Swallows gather together in immense flocks before leaving us. There are others again, such as the Cuckoo, which quietly steal away in pairs, or in very small flocks. Some birds in their flight remain close to the earth, while others fly at such a height that they remain unseen to the naked eye. Some move mostly at night, others in the daytime. Some birds migrate to the south, leaving their young

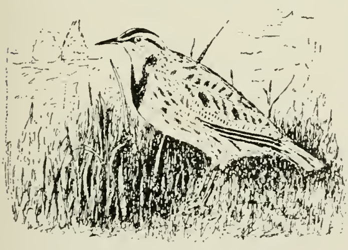


Fig. 60. The Meadow Lark.

to follow them at a later date. In most cases the males precede the females by some days in their return to us in the spring.

Before the snow is gone, we may hear the shrill piping notes of the Horned Lark coming from the plowed fields and meadows. The sound is not altogether unlike the pleasant note of the Meadow Lark. Early in March, the

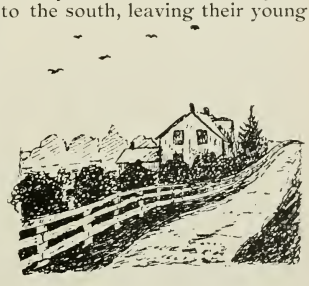


Fig. 61. The return of the Crows.

sharp-eyed, cunning old Crow bids good-bye to the southern parts of the Province and moves northward, with his head filled with new schemes whereby he hopes to grow fat and to render the farmer helpless to prevent his devastations of the fruit trees and corn fields. Then follows the Robin, whistling and strutting around with renewed vigor and grace. Then follow in rapid succession, Blue-birds, Song-sparrows, Black-birds, Phœbes, and a host of others, until the air is filled with music. Every tree, shrub. and meadow has its full orchestra.

Fig. 62. Taking Notes.

Every boy and girl should keep a record of the dates when the first of every kind of bird is seen each season. It will add greatly to the pleasure of spring-time.

Nesting Habits. Of all the evil traits which have been handed down to man, none is worse than the predisposition of the bad "small boy" to rob birds' nests. How much nicer it would make the home, if instead of driving the birds away in disgust, the boys would all fix up some nesting boxes in the old orchard, and upon the roof of the wood-shed. These need not be large nor expensive, and yet you will be astonished how soon the birds will use them as homes. Let every boy vie with his fellows to have the greatest number of birds summer around his home.

Here is a suggestion for you. Nail up some nesting boxes near your home, near by place some bits of string and hair that the birds may use in building nests. Then, if there is no water close by, set up on a post a tin dish that will catch the rain, and you can from time to time fill it with fresh water. This drinking place will attract the birds. Now keep track of the birds that come around, and, if you do not frighten them away, you will soon have some birds coming regularly to make their home with you. These new friends will be interesting, and you will be much happier in watching them coming and going through the summer than in frightening them away.

Fig. 63. Happy Homes.

Many of the birds are paired before they reach us in the spring, and soon they are busy making snug little homes in some secure and sheltered spot. The little workers labor industriously, all the while giving forth sweet melody. Birds differ widely in choice of places for their nests. The Horned Lark is satisfied with a shallow hollow in a meadow; while the Baltimore Oriole, trim of figure and bright of color, suspends its bag-like home from the end of some drooping bough, very frequently overhanging a stream (Fig. 64). The Bluebird prefers a hollow post or

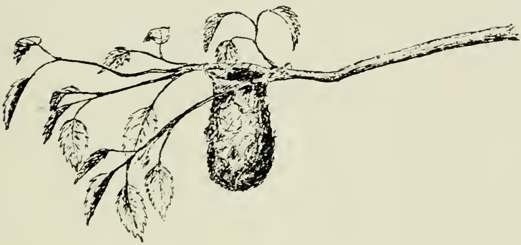


Fig. 64. The Oriole's Nest.

fence-rail; the Bank Swallow, a home made in a sand bank; and the Blue Heron, or Crane, as it is erroneously called, selects the lofty top of a tamarack or black ash wherein to build his home of sticks.

Watch carefully during the summer, and make a list of the birds which build their nests: *1st*, on the ground; *2nd*, in shrubs or trees not more than 15 feet from the ground; *3rd*, in trees at a greater distance than 15 feet from the ground; *4th*, in other places, as sand banks, eaves of buildings, chimneys, etc.

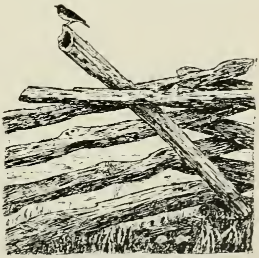


Fig. 65. The Bluebird's Nest.

Man and Birds. From an economical, as well as an aesthetical, standpoint, man should always be found offering protection to birds. This statement is made with full knowledge of the fact that there are a few members of this class of animals which are of little service to us, and are not distinguished for their beauty. Nevertheless, the fact remains that, as a class, we should offer them every protection, cultivate their acquaintance, and encourage them to build nests and remain with us. It is very doubtful, indeed, if there is a single species of bird for the total destruction of which we would be better off. Those who dispute this point have never made a careful study of the feeding habits of birds. Many unthinking persons condemn Woodpeckers, which are seen flying to and fro in the orchard, because it is

Fig. 66. Woodpeckers at work.

assumed that they are working injury. A careful field study of their food habits, and an examination of the stomach contents, would reveal the fact that these birds are destroying thousands upon thousands of injurious insects, particularly those which burrow in the wood. The orchardist sees the Robins carrying off a few of his cherries, and immediately some thoughtless boy brings out the shotgun, with the result that dozens of these hard working friends are destroyed. In all probability, had it not been for these birds, there would have been no cherries ; insects would have completely destroyed the foliage and fruit.

Definite information regarding the food habits of birds can be obtained only as a result of careful study and field observations, together with the examination of a large number of stomachs. A study along these lines frequently results in a complete change in our attitude towards the species under investigation. For instance, in the case of the Downy Woodpecker, an examination of a large number of stomachs revealed the fact that 13 per cent. of the food consumed, consisted of wood-boring beetles, 16 per cent. of bugs that live on the fruit and foliage, and a large proportion of the remainder is made up of scale insects, ants, and other such insects.

We might thus speak of all our common birds, and show that most of them are entirely beneficial ; and, as to the rest, their depredations are very small when compared with the beneficial service which they render to the gardner and orchardist. Farmers each year spend much time and money in keeping up the fight with aggressive and persistent weeds. Seldom do they realize that their efforts would be of little avail, were it not for the many varieties of birds which each year destroy millions upon millions of weed-seeds.

Birds have enormous appetites, and, as digestion is rapid, a large quantity of food is consumed each year. They eat during three hundred and sixty-five days of the year, so that, even though they do treat themselves to an occasional feed of luscious fruit, during two weeks of the year, we may rest assured that during the other fifty weeks they are with us they have rendered us services valuable far beyond the injury.

If the birds were destroyed, it is very doubtful whether after ten years a farmer or gardener could possibly bring any crop to maturity.

# THE STORY OF AN APPLE.

PROFESSOR H. L. HUTT.

FIG. 67.—McIntosh Apples.

One evening after tea, I had just settled down in my easy chair for a glance at the newspaper, when my trio of little folk pounced on me for a story. "A fairy story," said Jean "No, one about wild animals," said Fred. "I like to hear about what you did when you were a little boy," said Gordon. Here was too much of a variety to be given all at once; so I said, "Look at those beautiful red apples on the table." "Wouldn't you like to hear their story?" Fred was doubtful whether much of a story could be told just about apples; but I informed him that every apple has a history, and some have a very interesting one. 'What variety of apple is that?" I asked. "A McIntosh," they all shouted in chorus, for they had been learning the names of apples, and were always pleased to be able to identify a variety correctly. "How do you suppose it got that name?" I next enquired; but as this was too much for them, I said, "Well, that is where we will begin our story.

"Once upon a time (for all good stories begin that way), about thirty years ago, on a farm near Dundela, a little village in Dundas County, in the St. Lawrence Valley, lived a man by the name of Allan McIntosh. He was one of the early settlers in that section, and had cleared off most of the forest which once covered his fields, only a few acres of it having been left for bush. The bush was the favorite resort of the cows when the weather became warm and the flies were too troublesome in the adjoining pasture field.

"One evening, late in September, when Mr. McIntosh's little boys, Allen and Harvey, were hunting through the bush for the cows, they espied just on the edge of a clearing, a little tree bearing near its top a number of bright red apples. If they had discovered it sooner, they might have found many more on the lower branches. What do you suppose had become of them?" "The cows must have got them," suggested Fred. "Yes, the cows had found them first; but the boys were soon up the tree making sure that the cows would get no more of them.

"The apples were at that time hardly mellow enough for eating, but that did not prevent the boys from sampling them; and they declared that they were the finest wild apples they had ever tasted. Those not eaten at once were taken home and kept in the cellar till the family gathering at Christmas, when all present pronounced them finer than any of the named varieties grown in the little orchard near the house.

" Here then was a little tree growing wild without any care given it, yet it produced handsome apples of fine quality. How do you suppose it came to be growing there ? " " Somebody must have planted it," declared Gordon. " No," I said "it was not planted, but grew there from the seed, and was, therefore, what is called a chance seedling." "The Brownies must have planted it," remarked Jean. " Well, probably they did," I said, " but I think the Brownies in this case were the men who helped to chop down the trees in the woods ; for it is most likely that they had taken with them some Snow apples to eat when they felt hungry. They threw away the cores and when these rotted the seeds were left on the ground, and from one of these seeds this little tree may have grown."

" What makes you think they were Snow apples," inquired Jean. " Well," I said, " if you will fetch a few Snow apples from the cellar, to compare with those in the dish, you will probably find the reason yourself." In less time than it takes to tell, they were making comparisons, and they agreed that there was not much difference in appearance, except that the McIntoshes were, on the whole, a little larger and redder than the Snows. " What makes those black spots on the skin," asked Gordon, " they are on both kinds." ' Those," I replied, " are caused by a fungous disease with which the Snow apple and its relatives are often troubled. Now cut an apple of each kind and compare the flesh." " Why, they are both nearly as white as snow, aren't they?" asked Jean. " That is still further proof," I said, " that they belong to the same family. Now taste them." After much tasting of one and the other, it was decided that they were both so good that it was hard to say which was the better ; but when asked to shut their eyes and guess the name of the one they were given to taste, they found no difficulty in telling which was the McIntosh, because it had a " spicy flavor."

"Now," I said, "I think that you have sufficient proof that these two apples are related. In fact, there is little doubt that the McIntosh, and a number of other varieties I might mention, are seedlings from the Snow, or, as it is more properly called, the *Fameuse.* None of these varieties, however, take their names from their parent. The McIntosh, as you may have already guessed, received its name from the man on whose farm the first tree of that kind was found."

" But how does it come there are so many trees of that kind now ? " asked Fred. " We have them, and Grandpa has them, and lots of people have them." Well," I said, " that is one of the interesting points in the story of nearly all cultivated fruit trees.

" All of the McIntosh trees now growing in all parts of the country have descended from that one little tree in Dundas County, not by planting seed from it, for that most likely would have produced other varieties, but by grafting and budding other trees with cuttings and buds taken from it.

" One of the remarkable things about nearly all our cultivated fruit trees is, that trees grown from their seed show endless variations. If, for instance, you should plant 100 McIntosh apple seeds, probably no two of the trees from them would bear apples just alike, and most likely none of them would bear as good fruit as the McIntosh, although it is just possible that even better fruit might be produced. Some day you may find this an interesting thing to investigate."

Fig. 68. A glimpse in the nursery.

"But what do you mean by budding and grafting?" inquired Fred. "These," I replied, "are methods adopted by nurserymen who make a business of growing trees, whereby they can grow any number of trees that will bear the same kind of fruit, without varying, as they naturally would if the trees were grown from seed. These methods of propagating trees depend upon the fact that every perfect bud on a tree is capable, under favorable conditions, of producing another branch; or indeed, a whole tree of the same kind as that on which it grew.

"The McIntosh in our garden is a budded tree, which was obtained from Mr. Smith's nursery, where he grows thousands of other trees just like it. In growing these trees, Mr. Smith had in long rows in the nursery, thousands of little seedling apple trees (that is, little trees grown from apple seeds), which, if allowed to grow naturally would, he knew, bear a great variety of mostly inferior fruit, but he had heard of the excellence of the McIntosh apple, and intended to make them all bear McIntosh apples; so he wrote to Mr. McIntosh and got him to send all the young shoots he could spare from his McIntosh tree. From these shoots, which were obtained in July, Mr. Smith's men budded the little seedling trees in the nursery rows. The bark on each little tree was cut open near the ground, and one McIntosh bud was put in and bound firmly in place.

Fig. 69. Budding the seedlings.

By the end of the season, the bud showed by its plumpness that it had been adopted and nourished by its foster parent, and to all appearances it was much the same as any of the other buds, except for the scar around it showing where it had been inserted.

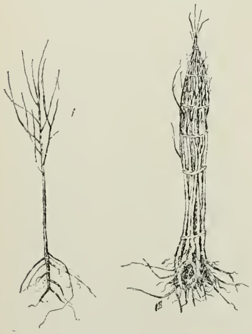
"Early next spring, however, each seedling tree was cut off just above the McIntosh bud, which was thus suddenly given the responsibilty of making a new top for the tree, and that is just what each little McIntosh bud did. In three years, each had made a little tree, big enough to be sold for transplanting; and that year they were all taken up and sent to the purchasers throughout the country."

No. 70. The adopted bud with scar around it.

"In Grandpa's orchard you may have noticed that the tree which bears the McIntosh apples bears also a few yellow apples." "Yes, Talman Sweets", said Gordon. "Well, that tree once bore all Talmans; but one spring Grandpa cut off most of its branches and grafted into the stubs left a few scions, or bits of twigs, from a McIntosh tree. These scions united with the growing part of the Talman tree, and produced large branches which bear the McIntosh apples, while the branches which were not grafted still bear Talman Sweet apples."

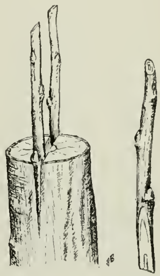
"By grafting into a large bearing tree in this way, Grandpa's tree was bearing McIntosh apples in three or four years; whereas our tree, being a young one, was nearly twice that old before it had apples on it."

"From the story of this particular apple, you will have learned how new varieties of fruits sometimes originate. Varieties found in this way



No. 71. Taken from the nursery and bundled for shipping.

No. 72. Old enough to begin bearing.



No. 73. How the grafting was done.

are said to be of chance origin. All varieties, however, do not originate by chance. Some are the result of careful and patient work on the part of men who not only gather and plant the seed, but contrive to have the new kind combine the good qualities of the two other varieties. If you will remind me of it next spring, when the trees are in bloom, I will show you how this may be done."

"From what has been said about budding and grafting you will also have learned how a new variety, once obtained, may be multiplied and scattered all over the country. If you would like to try what you can do at such work, you may begin next spring by planting a row of apple seeds in the garden; and when the little trees are big enough, I'll show you how to bud them, or how they may be made to bear fruit in two or three years by grafting them into a bearing tree. How many of you would like to try it?" "I, I, I," they all shouted; so we began operations at once by eating all the apples in the dish, to get the seeds for next spring's planting.

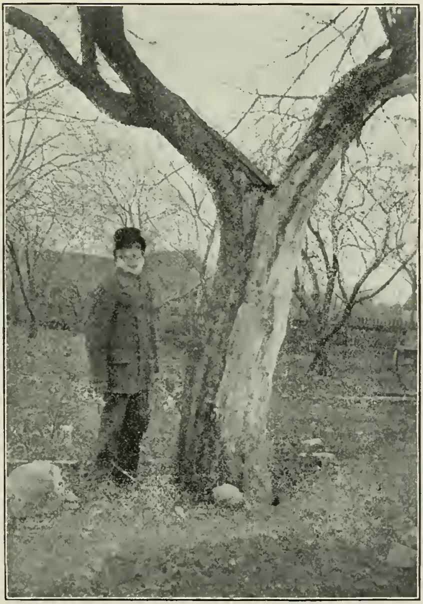


Fig. 74. Mr. McIntosh of Dundela and the original McIntosh tree.

# THE STORY OF SUGAR.

Professor W. P. Gamble.

From early childhood, the boys and girls of Canada are familiar with the substance called sugar. We all know that it is used in large quantities for the purpose of giving a pleasant taste to many of the delicious dishes prepared for our use ; but how many of my young friends have taken the trouble to inquire into the origin and manufacture of this useful substance ?

Fig. 75. The Maple in summer.

There are many kinds of sugar; but the one we shall speak of more particularly is the cane-sugar, so called because it was first manufactured from the sugar cane. Pure cane-sugar, as it appears on our market, consists of a mass of white crystals. If this sugar be heated to 320° Fahrenheit, it will melt to a colorless liquid, which rapidly assumes an amber hue, such as you have noticed when boiling it for the purpose of making taffy. If heated to a still higher degree, it turns brown, becomes less sweet, and gradually takes on a bitter taste. Old-fashioned brown sugar owed its color and flavor, in part at least, to this treatment ; for, as sugar was formerly made, in the process of evaporation over the open fire some of the sugar was browned or half burned. Cane-sugar was formerly sold more extensively than at present in the form of coarse brown sugar. To-day, with the improved methods of manufacture, we see very little cane-sugar placed on our markets in this form. You might think that cane-sugar, from its name, is found only in

Fig. 76. The Maple leaf and key.

Fig. 77. The Maple when it bleeds.

Fig. 78. Shows a branch of the Maple when growth again becomes active.

the juice of the cane, but not so. It is found also in Sorghum, a plant native to India, and now cultivated in the United States and in the south western counties of Ontario, near Lake Erie ; in certain palms, such as the cocoanut, and the wild-date palm ; in some kinds of grasses ; in the green stalks of corn ; in the Maple ; and in quite large quantities in the sugar beet. Maple sugar, on account of its unique and agreeable flavor, is now eaten chiefly as a luxury. This sugar, when freed from the color and flavor derived from the Maple, is identical in composition with that derived from the sugar cane. Most boys and girls in Ontario, especially those who live in the country, are familiar with the Maple, and the process by which sugar is obtained from it ; but why the sap runs from the Maple is not so well understood by the majority.

During the summer, the Maple is clothed with green leaves, which, through small openings on their underside, give off the excess of moisture taken up by the roots. Before the water is given off, the food which is held in solution is removed from it. This food goes to form a new growth of wood in the tree. In the autumn, the leaves of the Maple fall; and through the winter, the tree stands bare and does not grow. In spring, if the Maple is bruised or cut in any way, we notice that the tree "bleeds," or, in other words, "the sap runs." We have also noticed that the "bleeding" of the Maple occurs at different times of the year. The sap will run from the Maple before growth has begun, and just as it is beginning. In the two cases, the cause of the run of sap is quite different. We find a good example of both kinds of bleeding in the gathering of sap by the sugar maker. Sap is first gathered when the ground is still frozen, and the roots are therefore almost, or quite, unable to absorb any water ; but, at the same time, the air is warmed through the middle of the day by the increased heat of the sun. At this season, the flowing of the sap from holes or cuts made in the trunk of the Maple is due to the expansion by heat of the air inside the smaller branches and twigs of the tree. This sets up at once a pressure upon the sap, and this pressure extends to all parts of the tree. The sap with which the Maple is filled, is thereby forced out as soon as an opening is made for its escape. Later in the season, as the frost disappears, the roots begin to absorb water. This absorption process sets up a pressure within the tree, by reason of which the water is forced out of the same opening. "Bleeding," or the flow of sap, from this last mentioned cause, continues until the leaves are sufficiently expanded to throw off the water absorbed by the roots. The other source from which we in Canada obtain cane-sugar, is the

Fig. 79. Keys of the Maple separate. During germination a radicle is sent out which endeavors to obtain a hold in the soil.

sugar beet ; and, because of the particular attention which it is receiving just now in many parts of our Province, we shall study it with a view to finding out its life-story.

Beginning with the seed, we find that what is commonly called the seed is in reality a pod. With the aid of a sharp knife, let us open a number of these pods, by cutting them straight across the centre. We now notice that the pod is composed of a rough irregular shell. Inside the shell are chambers, separated from one another by woody partitions. In some of these pods, we find but one chamber ; in others, there are as many as four or five of these cavities. Inside each chamber, we find the true seed of the beet. The seed, you will notice, is kidney-shaped. It

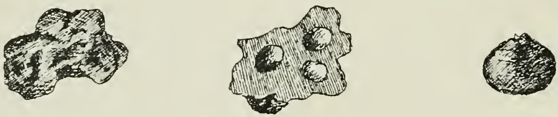


Fig. 80. The beet pod (on the left). The beet pod opened, showing the chambers within. The true seed of the beet (on the right).

is about the size of a turnip seed, and is enclosed within a dark brown wrapper. When this wrapper is removed, we discover the embryo, or infant plant, curved around a mealy substance. This mealy substance is the *endosperm*, and is the food upon which the young plant feeds during the germinating, or infant, stage. The embryo is the essential and most important part of the seed It has root, stem, and leaves, although these organs are often as undeveloped in form as they are in size.

Boys and girls will do well to observe carefully the various stages in the act of germination. For this purpose, a dozen pods or more are sown in a soil kept duly warm and moist, and one or two pods are uncovered and dissected at successive intervals of, say, 12 hours, until the process is complete. In this way, it is easy for us to trace all the visible changes which occur as the embryo starts to grow.

We thus notice that the seed first absorbs a large amount of moisture. As a result, it swells and becomes soft. The embryo enlarges, and shortly the shell bursts, and a sprout makes its appearance. In the figure given below, you will notice three sprouts making their exit from a single pod. Notice also that these sprouts have the same general appearance. Each sprout is called a radicle. In time, the radicle becomes the true root.

Fig. 81. A beet pod showing three sprouting seeds (on the right). The radicle making its exit from the seed coat (on the left).

In the process of germination, the young plant grows at first wholly at the expense of the seed. It may, therefore, be compared to the suckling animal, which, when newly born, is unable to provide its own nourishment, and consequently depends upon the milk of its mother. The *cotyledons,* or young leaves of the plant, during germination absorb the endosperm, and remain within the seed coat some time after the radicle has made its exit. When the plantlet ceases to derive nourishment from the mother seed, the germinating process is finished.

The baby stage in the life-story of the young plant is passed. It must now depend on its own exertion to supply the necessaries of life. For this purpose, the radicle buries itself in the soil, and sends out slender rootlets to gather in the food found there.

Fig. 84. Sugar Beet at full growth.

Fig. 82. Plantlet with two leaves expanded.

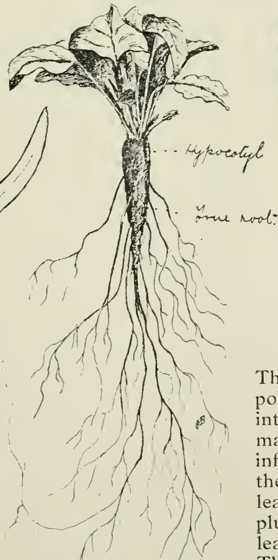



Fig. 83. Showing immense development of the root system of the beet.

The *plumule*, or growing point of the embryo, ascends into the air, in order that it may come under the direct influence of the sunlight. As the days pass, we notice new leaves unfolding from the plumule Why are these leaves sent forth by the plant? The leaves, like the root, are food gatherers. They absorb from the atmosphere substances which are necessary to the formation of plant food, and it is in the leaves that the manufacure or working over of those materials obtained from the soil and from the air takes place.

Let us now direct our attention to the root of the beet. Removing the earth carefully, we find that there is one well developed root pushing straight downward into the soil, and that smaller roots are sent out from it in two side rows. We notice also that for some distance below the surface of the soil the main root is smooth, and free from these smaller rootlets. How is it that so very little of the fleshy root of the beet appears above the surface of the soil? In reply to this question, we would ask you to observe the great length of these rootlets. "It has been frequently found that drains four and five feet below the surface of the soil have been blocked by them." As the rootlets develop, therefore, they exert a downward force upon the bulb, and this force tends to draw the bulb into the soil.

Conditions being favorable, the beet plant grows quickly. The main root thickens rapidly for a time; then we observe a less marked increase in size, and finally we can detect little, if any, development in this direction. During its development, small sacs, or cells, are formed within the root. These cells act as store-houses for the food material of the plant.

Let us again observe the leaves. The first thing that attracts our attention is the color of the leaf. Have you ever thought of the cause of this shade in the leaves of growing plants? It is due to the presence of a certain green substance known as *chlorophyll.* This big word has been made up from two Greek words that simply mean "leaf green." This chlorophyll plays a very important part in the life-story of sugar. The particular use of this green matter is to change the raw material into plant food. One of the chief materials of plant food is carbonic acid gas. This gas comes from the lungs of animals. All living creatures are continually breathing out carbonic acid from their lungs. This gas is poisonous to man, but is an essential food of plants. Without this food, the plant could store up no sugar, nor could it even live.

Fig. 85.—Shows the stem sent up from the crown of the beet. Second year of growth. The flower of the beet (in upper corner on right.) The ovary cut down through the centre (in lower corner in right.)

Carbonic acid gas passes into the leaves of the plant through small openings situated on the underside of the leaves. Large quantities of this gas are taken in by the leaves of the beet plant. This gas under the influence of chlorophyll is made to unite with water, and thus form a compound from which sugar is ultimately derived. After the sugar has been formed in the leaves, it is carried to the roots of the beet by the downward flow of the sap or juice. In the root of the beet, the sugar is deposited in cells, which very closely resemble those of the honey-comb in structure.

You will naturally ask : Does the beet go to all the trouble of manufacturing and storing up sugar for our special benefit ? Not at all. As you all know, the sugar beet does not produce seed during the first year of its growth. If we take a beet root from the cellar and plant it we observe that it again begins to grow. From the crown of the beet, a strong leafy angular stem is sent up. This stem bears the flowers which are the forerunners of the fruit. The flowers, you will notice, are arranged at short intervals along the stem and its branches, and are usually in clusters of four or five. Below each cluster is a small bract.

The flower possesses a perianth, which is composed of five small green leaves. The lower part of the perianth is united with a fleshy substance called the receptacle. We also notice five stamens opposite the perianth. The ovary, or sac, encloses a small body called the ovule. The ovule eventually changes into a seed or fruit.

After fertilization, the receptacle and base of the perianth of each flower enlarge considerably. In this way, the perianth of each flower becomes more or less firmly attached to each other. The fleshy portions, with the ovaries, eventually become hard. These spurious fruits finally come into the market as "seeds."

During the period of growth and development of the fruit, what has become of the bulb or fleshy root? Upon examination, we find that only the walls of the former bulb remain (Notice Figs. 84 and 85). What is the cause of this change ? The reply is : The store-house has become emptied of its contents. By what agency ? The sap or juice has carried it up for the young seeds in the course of their development. We see therefore, that the sugar and other contents of the cells in the roots were stored up by the plant for the purpose of supplying the food necessary to fruit or seed, production. In obtaining sugar from the beet, we, therefore, simply intercept Nature's plans, and are thus able to appropriate that which was not originally intended for us. This sugar is stored up by the beet plant in the root that it may feed itself the next season when it is forming seed.

We shall now examine the process of the manufacture of sugar from the beet. The beets are at the close of the first season removed from the soil, and are taken to the factory. At the factory, they are put into large sheds with V-shaped bottoms, which are connected with the factory by means of channels. Through these channels a moderate flow of water carries the beets into the first washing machine. By means of a spiral arrangement, the beets are tumbled about, washed, and carried along until they drop into an elevator. This elevator carries the beets to the top of the building, where they are weighed and sliced in such a manner as to open up the cells of the beet as much as possible.

We have already noticed that the cells of the beet in which the sugar is deposited are very similar to those of the honey-comb. Therefore, it is very important that the knives used in the slicing operation be sharp, so that the cells may not be ruptured, but clean-cut. As the slices come from under the cutter, they are put into large tanks. Warm water is forced through the contents of these tanks or jars. By the action of the water, the greater part of the sugar contained in the sliced beets is dissolved. You know how quickly sugar will dissolve in water. The water containing the sugar in solution is then withdrawn from the tanks and taken to a measuring tank. The part of the sugar beet left over, that from which the sugar has been extracted, is called "pulp." This pulp is of no further use in the manufacture of the sugar, and is therefore thrown aside or taken to feed stock.

After the liquid containing the sugar has been measured, it goes to the mixer, where it is mixed with lime, and then put into a large tank for carbonation. Carbonation is the process of converting the lime and other impurities in the mixture into an insoluble form, by means of carbonic acid gas forced through the bottom of the tank. The mixture is then poured into a filter-press. A filter-press is simply a large strainer, by means of which the insoluble matter is retained, as the clear sugar solution goes through. This process is repeated a second time, after which the solution is treated with sulphur fumes. The syrup is then boiled down to remove the water contained in it. This is done by passing the syrup through four large boilers. What is left after the boiling is called thick juice. This juice is again boiled in a peculiar kind of pan, called a vacuum pan, and now becomes raw sugar. The raw sugar is then run into centrifugals, which are machines used for the purpose of separating the white sugar from the molasses. At this stage, the sugar is, of course, damp. By means of a granulator, this wet mass, which has the appearance of snow, is dried. It is then run through sieves to separate it into fine and coarse grained sugar, and is ready for the market, clean, white, crystalline sugar, such as we use every day on the table. Some of the sugar that we use has been made from sugar cane grown in the West Indies or in South America, some has been made from sugar beets grown in France and Germany and Belgium. We cannot tell the difference between the two kinds—there is none. We shall soon be using sugar that has been grown in beets by the farmers of our own Province.

# THE STORY OF AN EGG.

W. R. Graham, B.S.A.

Everyone is familiar with the size and shape of an egg; but very few of us stop to think how wonderfully it is made. We all know that the contents of the egg are enclosed in a shell. This shell appears to be hard and solid, but this is not the case. True, it has much strength; but we find upon examination, that it is full of little holes. These small holes allow the air next to the shell to get into the egg. Thus it will be seen that we should keep the egg in a clean place, away from dirty straw, such as we often see in the nest; also away from strong-smelling substances, such as onions; otherwise, these strong odors, passing through the shell, will affect the taste of the egg more or less.

Next to the shell is a thin tissue. This tissue is made of two layers all over the egg, except at the large end, where they separate, forming a small open space, called the air-space. This air-space increases in size as the egg evaporates or dries. The longer the egg is allowed to remain in the air, the more air will pass through the shell; and each little particle of air carries away with it some of the moisture of the egg, and thus the contents dry up and the air-space increases in size. Sometimes eggs that have been left exposed to the air in a nice clean place for a year, are found to have very little content; and that which is left is dry and almost hard. These tissues may be pulled off the shell, especially in the case of a hard boiled egg.

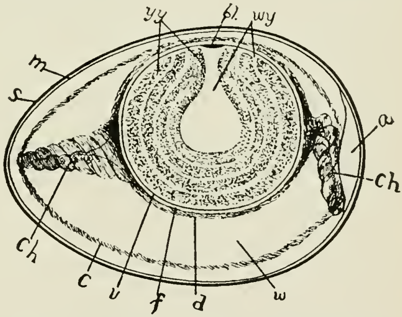



Fig. 86. Diagrammatic section of an unincubated fowl's egg: *bl* germ-spot; *wy*, white yolk, consisting of a central flask-shaped mass, and a number of layers concentrically arranged around it, the outer layer of white yolk lying immediately beneath the vitelline membrane, and connected with the central mass beneath the blastoderm; *yy*, yellow yolk; *v*, vitelline membrane; *f*, layer of more fluid albumen surrounding the yolk; *ch*, chalaze; *a*, air chamber between the two layers of the shell membrane; *m*, shell membranes, where they lie in contact over the greater portion of the egg; *s*, shell; *d*, denser albumen, which extends around the yolk, outside of the internal layer of more fluid albumen; *c*, boundary between the outer and middle portion of the albumen.

Now we come to the white of the eggs, or what is called the albumen. This is said by doctors to be a very good food; but we are particularly interested in its appearance. So let us break an egg in a saucer. Notice that the white on the outside is thin and watery; in a ittle farther, we see a grey or whitish streak that extends all the way around the yolk, or yellow portion, but does not touch it. You will also notice that at each end of the yolk and extending from this whitish portion is a knotted portion, like a little piece of white string. We wonder what these are for, and observe that they are simply an extended portion of this first white streak as mentioned. Inside the white streak is another watery portion. This comes in touch with the yolk. We shall now look at the yolk. Take your finger, or a blunt pencil, and try to turn it over, and you will notice that the covering of the yolk goes into all sorts of wrinkles and folds. So we find that the yolk is separated from the white by a thin layer of tissues or skin.

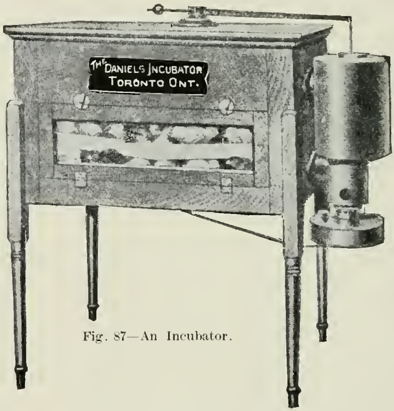


Fig. 87—An Incubator.

If you have been careful in breaking the egg, you will notice a little round spot at the top of the yolk This spot is about the size of a pea, and is called the germ spot; and it is from this that the chicken grows when heat and other conditions are properly applied.

To study further the structure of an egg, we will have one boiled hard; and, after removing the shell and lining tissues, we will tear loose a small piece of the white at the large end of the egg. Now by continuing to pull the torn portion from the left towards the right, you will notice that this white has a spiral arrangement. This is generally considered as giving strength to the egg.


Fig. 88.

We will next examine the yolk. Take the yolk out, cut through the centre, using a very sharp knife, and you will notice a small, flask-shaped portion of the yolk, which is soft and light in color, and that the neck of the flask extends to the outer edge of the yolk. Upon this the germ rests. The hardened portion of the yolk, you will notice, is arranged in regular rings around this flask. This flask-shaped portion is lighter than the rest of the yolk, and is therefore always uppermost. No matter how you turn the egg, this spot will be on the upper surface.

Let us ponder for a few minutes over the many things we have found in the egg content. The germ, resting upon a nice soft cushion in the yolk, the yolk covered with a thin skin, adjoining this is a very thin portion of the white, and outside this a thicker portion. Now these two portions hold the yolk in position. If a sudden jar occurs, the yolk, or chiefly the germ, is protected by the skin of the yolk. The thin white portion acts as a pad or cushion, and the thick white portion holds it steady. Those extended cords of the thick layer of the white act as the axis of the yolk holding it in position ; and, as you turn the egg around quickly, you twist the cords similar to twisting a string, with the result that, as soon as the egg is steady, these cords unwind, and help to right the germ spot, on the upper surface again.

No doubt by this time you are wondering, if this germ-spot and the portion of the yolk under it are so light, why the yolk does not come right up against the tissues lining the shell. But nature has guarded against this by the thick layer of albumen, which always tends to hold the yolk in position. Sometimes when the egg is left for weeks in the one position, the thick layer is overpowered, and the yolk touches the wall of the shell. If the yolk remains against the wall any length of time, it appears to become fastened to it, after which you cannot successfully hatch a chicken from the egg. Being fastened in one position, the germ cannot move properly in order to develop, the result being that the germ dies. You may say a hen sitting on eggs never moves them, but in this you are mistaken. The next hen you set, put a large pencil mark on each of the eggs; and place the eggs under a hen with the pencil marks uppermost. Next day lift the hen, and you will see that she has altered the position of the eggs.

We have to imitate the hen in running an incubator, in that we turn the eggs twice a day. But some one asks, what is an incubator ? Well, it is simply a well-built box, heated by a lamp, and the heat evenly distributed over all parts of the interior, so as to give the eggs the same temperature. This box is not exactly airtight ; for you know that if this little germ inside of the egg is going to develop into a chicken at the end of 21 days, it must have air. This air, you will remember, passes through those little holes in the shell, the good air going in, and the foul air coming off in much the same manner as you breathe. Now, you will see we have this incubator ventilated in order to supply the little germ with pure air. There is another point we nearly overlooked, that is the temperature.

If you will place a thermometer under a hen, you will notice that it reads 103 degrees ; so we try to run the incubator at that temperature.

If any of you would like to see that the germ spot always stays next to the surface, you can readily do so by taking a lamp after dark, and going to a hen that has been sitting four or five days. Wrap a black cloth around the lamp chimney, but first make a hole in the cloth, much the same shape as an egg, and have the hole exactly opposite the blaze of the lamp. Put the lamp on a little box, the hole facing you. Now very carefully remove an egg from under the hen, taking great care not to turn it over. Place your finger at the ends of the egg, and hold the egg in front of the light coming from the hole in the cloth that is around the chimney. If the egg is fertile, you will see a dark spot, and from this a number of little veins running in different directions. This is the germ, and it has started to grow. Now turn the egg slowly around, and you will observe that the germ moves as you turn the egg, always resting near the surface. It is best to take a white egg to see this, as white eggs are clearer than brown ones, and the germ is more readily seen through them. Should the egg appear clear, or no dark portion be seen, it is infertile, and will not hatch.

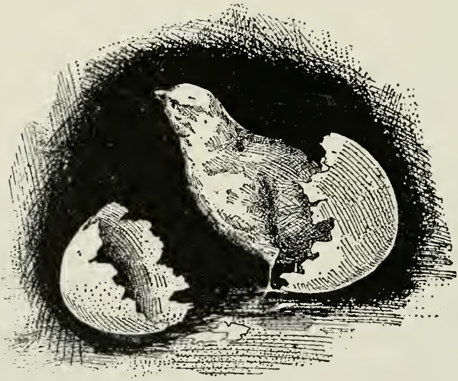


Fig. 89.—The latest thing out.

# THE STORY OF WOOL.

PROFESSOR G. E. DAY.

The next time you visit a fall fair, be sure you do not come away without going to see the sheep. If you are fortunate enough to visit one of our larger fairs, such as at Toronto, London, or Ottawa, you will find the sheep pens a very interesting place. Here you will see many different kinds of sheep; some large, some medium size, and same small; some with white faces, some with brown or gray faces, and some with black faces; some with their faces so covered with wool that they can scarcely see out through it, and some with no wool at all on their faces; some with horns, and many with no horns,—in fact, the longer you look at these beautiful creatures, the more you will find to interest you There is one thing about sheep that makes them look very different from all our other farm animals, and that is the warm coat which they wear. This coat is so thick and so warm that the sheep can stay outside in the coldest weather without minding the cold in the least, while a horse, or a cow, or a pig will shiver and look very uncomfortable indeed. Now, the horse, cow, and pig have coats, too; but their coats are made of hair, while the sheep's coat is made of wool, and wool makes a much warmer coat than hair.

Fig. 90.—Lock of wool, showing coarse crimp.

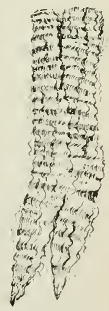


Fig. 91.—Lock of wool, showing medium crimp.

Did you ever think of what is the difference between wool and hair? If you part a sheep's wool with your hands, you will find that it is made up of a great number of very fine wool hairs, or fibres, which grow out from the skin of the sheep so close together, and so long, that they form a coat which the wind cannot blow through. After handling the wool, you will find that your hands are quite greasy. This grease, or oil comes from the skin of the sheep, and is called "yolk." It keeps the wool fibres soft and smooth, and keeps them from tangling or matting together. It also helps to keep out water, so that a sheep can stay out in quite a heavy shower of rain without getting its coat wet through. Then, again, if you look at these wool fibres closely, you will see that they are not perfectly straight, but that they have a wavy appearance. In some kinds of wool these waves, or bends, in the fibre are much closer together than in other kinds. Look at the two fibres shown in Figs. 90 and 91. In the first fibre there are very few waves while in the second the waves are close together. The finer the fibre is, the more waves it has, while wool with coarse fibre has very few waves.

These waves, or bends, are called the "crimp" of the wool. When the waves are very close together, the crimp is said to be fine, so that fine wool has fine crimp, and coarse wool has coarse crimp.

But there is another difference between wool and hair. If you get a single fibre of wool, and take hold of the end that grew next to the body of the sheep, and then draw the fibre between the finger and thumb of the other hand, you will find that it slips through very smoothly. But if you take hold of the other end of the fibre, and then draw it between the finger and thumb as before, you will find that it seems to catch, and does not slip between the fingers nearly so easily. Why is this? It is because every wool fibre has hundreds of very, very small scales on it, something like the scales on a fish, only so small that they cannot be seen without looking at the wool with a microscope, which makes the wool fibre appear many times larger than it really is. These tiny scales all point towards the outer end of the wool fibre, so that when you took hold of the outer end of the fibre and tried to draw it between the fingers of the other hand, the points of these little scales caught on your fingers and made it hard to pull. The picture, Fig. 92, shows how these scales grow on the wool fibre, but the fibre and scales are made to appear very much larger than their natural size. Hair also has scales upon it, but the points of the scales on the hair are rounded, and they lie so close to the hair that they do not catch hold of anything they rub against; while the scales on the wool fibre have sharp points and rough edges, so that they catch and cling to everything they touch. This difference in the kind of scales, is the most important difference between wool and hair.

Fig. 92.—Wool fibre, showing scales.

Now, when the weather grows warm in the spring, the sheep does not need its warm winter coat and so the farmer clips it all off, or shears the sheep, as we say. The wool is then sold, and is sent to the large factories where it is made into all sorts of clothing, blankets, yarn, and other goods.

Before it is made into cloth, the wool is twisted, or spun into yarn. If the wool fibres had no crimp, they would not stay tightly twisted together, and the yarn would be of very poor quality. Then the yarn is woven into cloth by machines, and the way the wool is handled in spinning and weaving causes the little scales, which we have described, to catch into one another, and the wool fibres become all tightly matted, or felted together, making a firm, strong piece of cloth. From what has been said, you will see the use of the crimp and the scales of the wool. The crimp makes it possible to twist the wool into yarn which will not easily untwist again, and the scales cause the wool fibres to stick together, or felt.

It would take too long to describe all the different things that can be made out of wool; so we shall mention only a few of the principal classes of goods. Wool that is very long, strong, and coarse in fibre is often called "braid" wool, because it is from such wool as this that braid is made. Then there is other wool, not quite so coarse as the braid wool, but still quite long and very strong in fibre ; this is made into what are called "worsted" goods. Worsteds are used very commonly in making men's clothing. Some sheep produce wool that is quite long and yet very fine in fibre. Wool that is between two and three inches long and very fine in fibre usually sells for a higher price per pound than other kinds. It is used very largely for making ladies' dress goods, such as delaines, and is often called "delaine" wool. Wool that is short and fine in fibre is used for making such goods as broadcloth, fine underclothing, tweeds, and other goods of that kind. Some wool that is long and coarse has weak spots in its fibres ; and any wool that has weak fibres cannot be used for delaines, worsteds, or braid, but is made into cheap tweeds, blankets, coarse underclothing, carpets, coarse stocking yarn, and such like. Thus, you see, there are many kinds of tweed, underclothing, blankets, and such goods, depending upon the quality of the wool that is used in making them.

Such goods as delaines and worsteds have a smooth surface. This is because the wool is put through machinery which stretches the wool hairs out straight, and they are then twisted together in such a way that all their ends are tucked in out of sight. This stretching is called "combing," and the wool fibres must be sound and strong in order that they may not break during the operation. But if you examine a piece of tweed or blanket, you will see the ends of the wool hairs standing out from the surface, making the material look rough. This is because the wool has not been combed, but has been put through a process called "carding," in which the wool is rolled up in such a way that when it is spun, the ends of the wool hairs stand out from the yarn and give a rough appearance to the cloth after it is woven. As a rule, wool that is less than two inches long is not combed, but is used for carding ; and wool that is weak in fibre will not stand combing, and therefore must also be carded. There are many other interesting things which might be said about wool, but I shall simply ask that whenever you see a sheep, you will think of what you have learned about the wonderful coat it wears, and remember that we should always be kind to these gentle and timid animals because we owe to them much of the most beautiful and most comfortable clothing which we wear.

# TOMBOY—THE STORY OF A COLT.

J. HUGO REED, V. S.

I am a four year old filly. My name is Tomboy. My mother is a half-breed, and her name is Duster. My sire's name is Jim Wassen; he is a thoroughbred. Therefore I am three-quarters bred. My mother is a large white mare, a great favorite of my master, who both rides and drives her. She is a grand saddle mare and hunter. She likes to gallop across country after the hounds with my master in the saddle. She jumps over fences, ditches, stone walls and anything that is not too high; she can

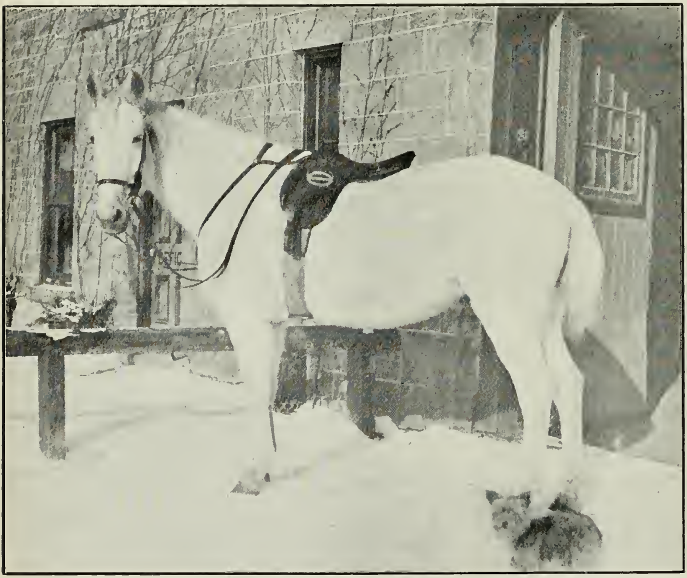


Fig. 93. Tomboy's Mother, "Duster,"—26 years old.

run fast and jump better than the other horses in the hunt. She is large and strong, and although my master weighs 200 pounds, she likes to carry him as he is kind to her, rides her well, and never pricks her sides with the spurs, nor hits her with the whip, nor hurts her mouth by bearing too heavily on the reins. He has always been kind to her and fed her well, and that is why she is strong and sound and as lively as when she was young, although she has done a greal deal of hard work in both harness and saddle.

The first thing I remember was one Sunday morning in May, 1898, when my master and Ernest, his stable man, came to the stall where my mother and I were. I was only about one hour old, but I was walking around the stall. They looked at me for a while, and then my master came into the stall and put his hand on me and spoke kindly. I was afraid at first and ran behind my mother, but he followed me, saying, "Poor little thing, do not be afraid, I will not hurt you;" so after a little time my fear left me, and I have never been afraid of him since, as he has always been kind to me, and provided me with a nice clean box stall with plenty of straw to lie on and good food to eat, and he never works me too hard. That morning, after looking me carefully over he said, "Well my little beauty, I am glad that you are a filly ; you are tall enough but rather too slim, but time and good care will cause you to grow stouter ; your knees are rather weak but they will grow strong after a while ; I will call you Tomboy; and if you make as good a mare as your old mother you will do well." He then gave my mother a nice feed of warm bran and crushed oats and a drink of water. He told Ernest to clean the stall out and put in a liberal supply of clean straw. I liked to lie on the straw, and did so most of the time for a few days Whenever I got hungry I got up and took some milk and walked around a little. My mother did not lie down for three days after I was born; she appeared to be afraid to do so for fear of hurting me. My master and mistress came to see me often, and would always pet and handle me. I liked to see either of them come, and would always walk up to them to be petted. Ernest gave my mother her food and water, and kept the stall clean and well supplied with straw. He likes horses and was very kind to us, and we both liked him, and would do what he told us. When I was three days old, my master put a little halter on me and Ernest put one on my mother and led her out of the stall. I was not afraid, but did not know what to do. My master, however, was kind and did not get angry and jerk or hit me, but petted and coaxed me ; he did not expect me to lead the same as a horse that had been trained to it; so I soon learned what he wanted me to do and went along with him. They took us to the yard between the stable and the house. I forgot to tell you that we live in town. There was some nice grass in the yard; and as soon as our halters were taken off and we were given our liberty, my mother commenced to eat it. The day was fine and warm, and it was nice to be out in the open air. I began to run around my mother and kick up my heels.

My master and Ernest stood and watched us and laughed at the fun I was having. Master said, "That is right, Tomboy, have a good time but do not hurt yourself, you are not very strong yet, and a little sun will do you good." When I became tired I lay down and stretched myself out in the sun. All this time my mother continued to eat grass, but would often look to see that I was all right ; she was very proud of me. After a little while some bad boys came along and threw stones at me, one of them hit me on the head and hurt me. I jumped up and ran to my mother; the boys continued to throw stones and mother became greatly excited ; she galloped around and whinnied, and my master heard the noise and ran out He was very angry at the boys, and told them that if they ever threw stones at me again he would horse-whip them. We were then taken back to the stable. We were taken out to the yard every fine day after that and left there for a few hours, and I soon became stronger. When I was two weeks old I had my photograph taken. You can see by it that I was tall and slight, and that my knees had not yet become quite straight. When I was about three weeks old we were taken out as usual. A third man was leading my brother, who was a year old. His name is Banbury. Instead of leading us to the yard as usual they took us in the opposite direction, down a long street, until we came to a gate. They led us through this gate into a field, took off our halters and set us at liberty. There was plenty of good grass in the field and a stream of nice cool, clear water running through it. Banbury and I had any amount of fun running and kicking up our heels ; our mother would occasionally join us in our frolic, but usually she would just look on. I soon discovered that grass tasted nice, and I used to eat all I could. The weather was warm, and we stayed in the field day and night. There was plenty of grass and good water, and we had a good time with nothing to do but eat, drink, play, and sleep. After a while, the grass became rather dry and less plentiful, and the flies began to torment us during the day time. Our master soon noticed this, and every morning, about the time that the flies were beginning to trouble us, he would mount his wheel and ride down to the gate, which he would open. Then he would whistle; and as soon as we would hear him we would all gallop up to him, when he would put a halter on my mother and lead her out of the gate. We would follow, and he would then shut the gate, mount his wheel, and start towards home. Banbury and I would sometimes run ahead and sometimes lag behind ; but we never got far away. We all were taken to the stable and put into our stalls, the windows of which were darkened to keep the flies out. Ernest then gave us some nice new hay and crushed oats, having nailed a little box up in one corner of the stall, just the proper height for me to eat out of. I was too small to reach my mother's feed box. When evening arrived, we were taken back to the field, as the flies did not bother us now, and it was better for us to be out than in the stable, and we liked it better. This was done every day until the weather became colder in the fall, and the nights were so cold that we would be uncomfortable in the field. The flies had mostly all disappeared by this time, so we were kept in the stable at night and turned out in the day time. After a time the weather became so cold that we were not taken

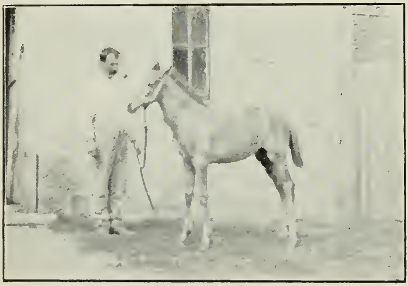


FIG. 94.—Tomboy when two weeks old.

to the field at all, but were allowed to run out in the yard for a few hours every fine day. The time soon arrived when I had to be weaned. I was taken to a nice stall in a part of the stable distant from my mother. I did not like to be taken away from her. Neither did she like to be left alone. I was taken to her stall and left with her for a few minutes three times a day for three days ; then twice daily for three days ; then once daily for a few days ; after which I was not allowed with her at all for a long time. By this time, I had grown quite stout and strong, and my knees had become straight, as my master said they would the first time he saw me. I was fed all that I could eat the first winter. Ernest gave me good hay and scalded chopped oats, with a carrot or two every day, and twice weekly he gave me a feed of bran. My stall was kept clean and well supplied with straw, and I was allowed to run out in the snow with Banbury every day that was not too cold or stormy. My master used to trim my feet every month. He said that the wear was not equal to the growth, and that if he did not keep them trimmed to the natural shape there was danger of them becoming ill formed and injuring me for life. He used to put a little bridle on me and leave it on for an hour or two every day. He said this was to give me a mouth. By that he meant to accustom me to the bit. I did not like it at first, but after a few days I did not mind it in the least. Then he put a set of little harness on me and left it on for a few hours daily. He soon put a check rein on the bridle. A portion of this rein was elastic. He fastened the rein to the check hook, but did not check me up tightly.

When I poked my nose out the elastic would stretch ; but when I relieved tension it drew my nose back to the proper position. He said that this would gradually teach me to yield to the restraint of the bit, give me a good mouth, and thereby make me a more valuable horse, and more pleasant to ride or drive. I did well the first winter, and I learned a great many things that came very useful afterwards. When the grass became plentiful and the weather fine in the spring Banbury and I were taken out into the country and turned into a field on the farm of Mr B. This was about the end of May. Our master told Mr. B. to watch us closely, and if we should not do well to be sure to let him know. The grass was very nice, and there was a stream of clear, cold water running through the field. We enjoyed ourselves very much, and resumed the sports of the previous summer, as we were always great chums and never quarreled. In two or three days I began to feel unwell, my throat became sore, and I could not swallow easily. I felt cold all the time, although the weather was warm. I did not feel well enough to play with Banbury. I grew worse day by day. The soreness of my throat increased until I could not swallow anything without feeling great pain; my eyes became sore, tears ran down my cheeks, and I could not bear to look at the sun. My joints became sore. I had a painful cough and a discharge of mucous from the nostrils. Mr. B. saw us every day. One day he said to his son, "The filly has a cold, but I guess she will soon get over it." The son said, "But, father, you promised to let Mr. R. know if anything went wrong with the colts. You know he is very fond of them, and you should send him word about it." Mr. B. said, "I'll think of it some day when I am in town." I gradually became weaker, as I could neither eat nor drink. One day we saw our master coming down the lane, and we were both very glad. (Banbury was quite well, but was very anxious about my condition). We knew that he would do something to help me. As soon as he saw me he said, "Poor Tomboy, how you have failed. What is the matter?" Mr. B. was there, and after our master had examined me, he said to Mr. B., "Why did you not let me know that the filly was ill? You are in town mostly every day." He said that I had influenza, and that it would require very careful nursing to pull me through. He was very angry with Mr B. for not telling him. He took both Banbury and me home. I was very weak, and we had to go slowly. When we reached home he rubbed something on my throat and gave me some medicine, which did not taste nice but did me good. He and Ernest gave me a great deal of attention, and my throat soon got better, and I was able to eat. When I got strong enough he turned us out to pasture on Mr. W.'s farm, where we remained until the weather became cold, when we were taken back to town. The following winter we both did well. One day my master put a set of harness on me and drove me out on the street. I was so accustomed to harness and to do as I was told that he had very little trouble with me. He did this a few times, and then he hitched me to a light cutter. It was something new for me to have to draw a load but I knew that it was all right, else my master would not ask me to do it. He walked behind at first, but I went all right, so he got into the cutter and I drew him too. He drove me a little every day for a couple of weeks, and I heard him tell Ernest one day that I was pretty handy now and would never give any trouble in harness. The next spring we were again turned out on good pasture and again taken to the stable in the fall. We were well cared for during the following winter. Banbury did some regular driving, and I was driven some to continue my education. The next spring Banbury was four years old and I was three. One day a man came to the stable and looked at all the horses. He asked if Banbury was for sale, and my master said, "Yes, I will sell him; he will make an excellent lady's saddle horse." The man said that he wanted him to send to South Africa with the mounted infantry. My master then said, "Well, you can not have him, as I will not sell him for that purpose;" so the man went away, and I was glad that he could not get Banbury to send to the wars. After a little while a lady came to the office one day and asked my master if he had a good saddle horse to sell. Banbury was taken out for her inspection. She liked his looks and asked if she might ride him. My mistress's saddle and bridle were put on him, and the lady mounted and rode away. When she came back she said she liked him, that his paces were good, and he had an excellent mouth and good manners. She bought him. I was sorry to see him leave the stable, but glad that he had been bought by a kind lady who wanted him for herself. My master saw him a few months later, and I heard him tell Ernest that he looked well, that he was homesick for a few weeks, but was now quite contented and happy in his new home, that his mistress was kind to him and very fond and proud of him. One day Mr. T., a friend of my master's, asked permission to ride me. He was told that I never had been ridden, that I was of a nervous, sensitive disposition and required very gentle, kind treatment, and that he would like to ride me first himself but was too heavy for me. Mr. T. said that he would like to try me, so a saddle and bridle were put on me, and I was taken out to a vacant lot. My master held me while Mr. T. mounted, and then led me for a while. I was afraid, as I never had weight on my back before, but while my master went with me I knew that it was all right and I went nicely. He said to Mr. T., "Now, I will let her go; be gentle with her and do not worry her mouth ;" so he let go. I became nervous then and made two or three plunges. Mr. T. sat me well, was easy with my mouth, and spoke kindly to me, so I settled down and walked along quietly. Mr. T. then said, "So my lady, you thought you could unseat me, but I will teach you that I am master here." He then drew heavily on the reins and hurt my mouth, and he hit me a smart cut with his whip, which caused me pain. This made me angry, as he had no right to punish me when I was acting nicely ; so I bucked and threw him off. He alighted heavily on the hard ground ; and I stood still until he got on his feet. My master came to me and caught the bridle ; he asked Mr. T. if he was badly hurt, and told him that he should not have punished

Fig. 95. The colt gives a lesson.

me. Mr. T. said that he was not badly hurt and that he would mount again, which he did; and as he used me kindly I did not throw him again. The next day I heard my master tell Ernest that two of Mr. T.'s ribs had been broken by the fall. I felt sorry, but really it was his own fault. After this I was ridden daily by Ernest. He was kind to me, and I acted well. I soon became handy, and Ernest said that I was very easy to ride. One day my mistress asked if she might ride me; and my master said yes, that I was perfectly safe. So they put saddles and bridles on me and my mother, and my mistress and master rode us. After that she rode me often, and said that she liked me better than her own saddle horse. She sits me well and has very light hands. I like to have her ride me. She says that I walk, trot and canter well, and that my mouth is perfection. One day she asked me to jump a ditch, and I did it so well that she tried me over fences. I like jumping ; I think I inherit the liking and ability to jump from both my parents. When the hunting season commenced, my master rode a big bay half-breed that he calls Pharoah, and my mistress rode her big bay half-bred mare, Dorothy. There are so many barbed wire fences and so many swamps around here that they cannot hunt foxes as they do in some countries ; so the huntsman rides across the country with a ball soaked in oil of anise trailing after him. He avoids swamps and barbed wire fences. Then the club comes out on horseback, and the huntsman brings the hounds out. The hounds scent the anise, and follow the course that the huntsman had gone. This is called hunting a drag. The hounds make a lot of noise, which is called giving tongue. I heard my master tell the huntsman one day to make a short run, as he wanted to try Tomboy across country, and that he would ride Duster ; that the one was too young and the other too old for a long run, and to make it about four miles. So we were taken out one afternoon. My master rode my mother, and my mistress was up on me. As soon as the hounds came in sight I noticed that my mother became excited. She pawed the ground and champed the bit and wanted to be off. I did not understand it, as I saw nothing to be excited about. There were about twenty ladies and gentlemen in the saddle. After a while the hounds scented the drag, and one of them gave tongue. My master said, " Old Cecil has found, it ; steady Duster, steady."

Away the hounds went over the fence. My master had his hands full controlling his mount, but he managed to steady her and said to my mistress, " Now, I will give you a lead ; steady her well at her jumps." He gave my mother her head and took the fence. I followed and off we went after the hounds. The other riders followed. My mother was very anxious to go fast, but her rider held her in, and said to my mistress, "Keep Tomboy back for a while ; we will save our mounts at first, and see if the old mare and her daughter cannot beat them all out at the finish." I soon understood my mother's excitement, as I was becoming excited too, and anxious to run to the front. Our riders held us back without being severe or cross with us, and we jumped everything that came in the way. We enjoyed the sport as much as our riders. My mistress talked to me and praised the way I was carrying her, and said that she would let me have a brush with my mother at the finish. By this she meant that she would let me try to outrun her. I would rather have gone faster, but wanted to please my mistress, and I knew that she was the better judge. Some of the riders were ahead of us and some were behind as their horses refused to jump. We went along steadily and did not make any mistakes, but took our jumps well. After we had gone about three miles we noticed those in front of us stop short. The riders took their mounts back and then turned and whipped them ; after which they ran to a certain place and balked. Two of the riders went forward over their horses heads and were lost to view, while the horses galloped over the field with empty saddles. My master said to my mistress, "They have come to a stream and the horses refuse to take water." He meant that they would not jump over the water. " It is a broad jump and our mounts will require speed to take it ; steady Tomboy and follow me, but do not whip her." He gave my mother her head, and she went fast, with me close up. We passed through the other horses and both jumped the stream with ease. The hounds had lost the scent and were running around the field without making any noise. We came to a standstill and got a rest. Our master blew his horn, when every hound raised his head and looked towards us. He blew again, and they all came to us. In the meantime, some of the horses got across the stream, but some would not take it. Master told the hounds to hunt and Cecil again found, and gave tongue. The others soon joined her, and away they went, making a great noise. Both my mother and I were excited now and anxious to be off, but our riders controlled us until the hounds got well away, when our master said, "We are near the finish now so let us have a brush and try Tomboy's mettle." They gave us our heads and off we went side by side. I was anxious for my mistress to win ; but my mother can run fast even though she is old. We left the other horses behind. There was an open gate leading into the road, and about a quarter of a mile off we saw the hounds had lost again, and we knew that this was the finish. We ran down the road very fast; and just at the last I got about half my length ahead of my mother and won.

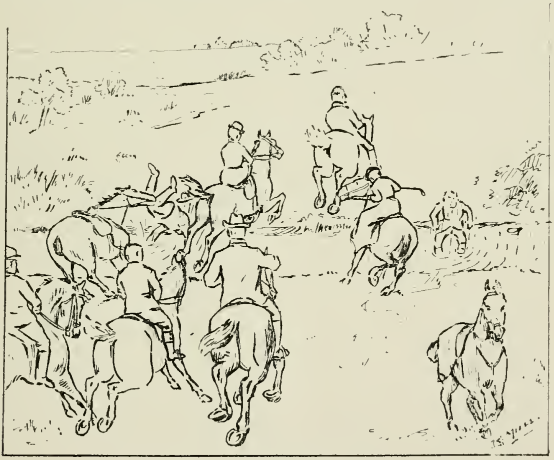


Fig 96.—Tomboy and Duster lead the way.

I think she allowed me to do so, but she will not admit it. This was near home; so we were ridden home; and my mistress gave me great praise and said she would never allow me to be sold, but would keep me for her own saddle horse. I was glad that I had done so well, as I liked my mistress and had a good home, and a horse never knows what kind of a master he will get when he is sold. We were taken home and given a few mouthful's of water, put into our stalls, and given a nice warm mash each, rubbed until we were dry, and bandages put on our legs, and left on for about three hours. The next day we were given some walking exercise, and we both felt quite fresh. My mistress intends to ride and hunt me regularly; but my master says my mother is too old for such violent exercise, and he does not think he will hunt her again. He says he will keep her as long as she lives ; that it would be mean to sell so good a servant in her old age, and that he could not bear to see her owned by any person who might not be kind to her.

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 125.

# ROUP

BY

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ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 125.



# ROUP

BY

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and DR. H. STREIT, Assistant in Bacteriology,
Ontario Agricultural College, Guelph.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
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Ontario Agricultural College and Experimental Farm

# ROUP.

By Prof. F. C. Harrison and Dr. H. Streit, Bacteriological Department of the Ontario Agricultural College and Experimental Farm.

The most widely spread and destructive disease affecting domestic fowls in Ontario, and perhaps in Canada, is commonly known as *Roup*, Canker, or Distemper. By some, the disease is called Cancer of the Mouth, Throat, etc., or even by the name of Fowl Diphtheria; but all these different names are given to the same disease, according as some particular symptom is more or less prominent

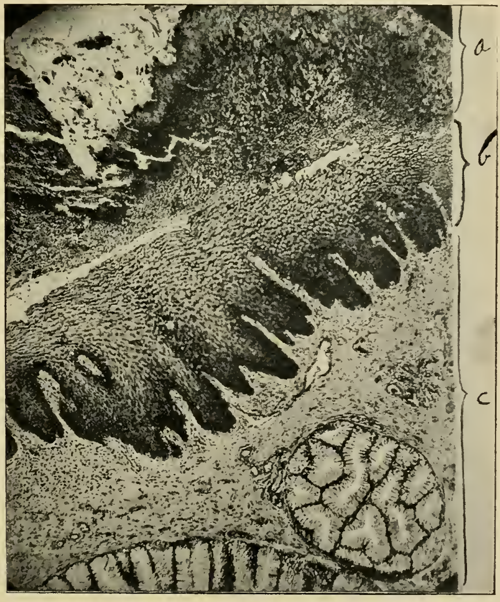



Fig. 1.—A section of false membrane of a roupy fowl. *a* False membrance. *b* Epithelium. *c* Submucosa.

*Economic Importance.* The economic importance of this disease is very great, as it is probably one of the greatest hindrances in the poultry business. The direct losses from the disease vary greatly in different epidemics. Thus, in a virulent outbreak, there may be many deaths in a short time; while, in another, a flock may become infected and only a few birds die. Of much greater importance are the indirect losses; and these are apt to be overlooked by farmers or those who keep only a few fowl and pay but little attention to them. The diseased birds recover very slowly; and they remain thin, anæmic, and unfit for egg production, fattening, or breeding,—eating just as much as if they were normal and living at the expense of their keeper.

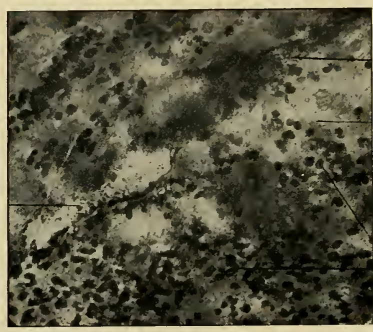



Fig. 2.—Section of a false membrane (portion of (*a*) Fig. 1, more highly magnified) showing pus cells (*p*), fibrous exudate (*f*) and bacilli (*b*).

## General Condition of Roupy Birds.

The general condition of roupy birds varies very much. After the first symptom of the disease, which is usually a putrid catarrh from the nostrils, the affected fowl is generally restless, separates from other members of the flock, becomes dull, cowers in the corner of the coop, or mopes in the corner of the pen, with its head drawn close to its body and often covered with its wings.

If there is a severe discharge from the nostrils or eyes, then the feathers upon the wings or back are likely to be smeared with it, stick together, and after some time fall out; and the eyes are often shut, the lids being glued together by the sticky discharge from them.

A fowl in a sleepy condition, or moping as described, frequently rouses itself for a time, takes food, and especially water, and then gradually returns to the apathetic condition.

Many fowls having the disease in a chronic form keep their normal appetite for a long time, and seem very little disturbed physically, whilst others, especially when the face or eyes become swollen, lose their appetite, grow thinner and thinner, and finally become too weak to stand or walk around, when they lie down and die in a few days. During the last stage, diarrhœa, with offensive yellow or green discharge, often sets in and causes death in a short time.

Many poultry keepers assert that roupy birds show fever; and it is certain that the head is very often hot, but the body temperature is normal, or only very slightly higher than normal.

## Special Symptoms of Roup.

By the term Roup we generally understand a more or less putrid discharge from the nostrils, which lasts for weeks or even months. The disease often follows a common cold, to which fowls, especially

Fig. 3.—Pigeon (No. 6) thirteen days after inoculation with the roup bacillus and two days before death.

young fowls and those of the more delicate breeds, are much predisposed.

In the first stages of Roup, the birds often cough or sneeze, and the breathing is noisy, caused by the partial closing of the air passages, which become blocked with the discharge from the nostrils. When the air passages are entirely closed by the discharged products, the fowl has to open its beak in order to breathe.

Sometimes a yellowish cheese-like mass forms in the nostrils, growing quickly and pressing the upper walls of the nose upwards: and if this mass is removed, an uneven bleeding surface is left, which forms a new cheesy mass in from 24 to 48 hours.

Whilst many roupy birds show only the above mentioned symptoms, others become more seriously diseased. The face o roupy birds is very often swollen, especially between the eyes and the nostrils ; and this swelling, which is hot and sore, sometimes grows into a tumour as large as a walnut,—generally firm and hard. A bird in this condition is frequently found scratching at the tumour with its claws or wings, as if endeavoring to remove it. If the tumour grows on the inner side, towards the nasal passage, it forces the roof of the mouth downward, and the upper and lower beak are slowly pressed out of their normal position, so that the bird cannot close its mouth.

On making an incision into the tumour, we find a solid, cheesy, yellowish matter, which may be pulled out like the root of a plant ; but it usually has to be broken into small pieces in order to get it out. Around this mass, there is a more or less smooth, grey or brownish membrane that is capable of again forming a cheesy mass similar to what has been removed.

The mass itself, when not attended to, often grows into the nasal canals, and blocks them up completely. Generally, combined with the formation of the tumour on the face, there is an affection of the eyes ; or the eyes become diseased without the preliminary discharge from the nose, in which case poultry keepers speak of fowls as suffering from " Roup of the Eyes."

*Roup of the Eyes.* The first symptom of the eyes is generally an inflammation of the eyelids. These become red, swollen, and hot ; then the mucous membrane and glands of eyes become inflamed and begin to secrete a liquid,—at first clear, and then of a grey slimy, putrid character. Occasionally the mucous membrane of the eye socket is the primary seat of the infection of the eye, and the eyelids swell as a secondary symptom. It is easy to understand that the eyes may become infected from the nasal cavity, as the eye socket has free connection, by means of the lachrymal canal, with the nasal cavity, and thus the diseased products from the nostrils can pass into the eye sockets.

The secretion from the eyes is similar to that described as coming from the nostrils, *i. e.*, at first a clear liquid, then changing to a putrid grey and offensive discharge, which dries on the feathers at the side of the head, causing them to stick together or fall out. If the secretion is retained in the eye socket, it undergoes a change, becoming a yellowish, solid, cheesy mass of the same appearance as that found in the nasal tumour. This cheesy mass either forces the eye out of its socket, or the imflammation entirely destroys it. These cheese-like masses form in one or two days, and may reappear after many daily removals.

All these affections, described above, may be localised on one side; but often both nasal passages and both eyes are affected at the same time.

Combined with the symptoms of roup above described, there often are patches of a greyish yellow exudation firmly adherent to the mouth, throat, etc. These patches are called " false membranes "; and on account of their somewhat close resemblance to the membrane which is formed in human diphtheria, it has been thought by some writers that the avian and human diseases are the same. Here, however, let it suffice to say that the weight of evidence is against this contention; but this phase of the subject will be more fully dealt with later on in this bulletin.

We may also point out that many poultry keepers who notice the false membrane on the throat and mouth of their fowls, regard the disease as quite different from the catarrhal form and call it "canker", which is probably a popular form of the word "cancer".

Whether the disease is characterized by false membranes, offensive discharge, or cheesy masses, the cause is the same, as we have many times experimentally demonstrated.

Fig. 4.—Hen 47; sixty-seven days after inoculation with B. pyocyaneus and the day before death.

At one or several places in the mouth or throat, these yellowish, smooth or uneven membranes appear, and either remain small and disappear after a few days, or grow thicker, spread, and become firmly attached to the mucous membrane; and if they (the false membranes) are removed, an uneven, bleeding surface is exposed, which looks like a true cancer.

After the appearance of the membranes, the adjacent submucous tissue sometimes becomes inflamed, and finally the growths are found to be similar to those so often seen at the side of the face,—containing solid cheesy matter in the centre.

When the throat is blocked by these false membranes, the animal's breathing becomes abnormal, and the air passing through the throat produces loud noises. Gradually, the visible mucous membrane and the comb turn blue, and the fowl finally dies from suffocation.

The symptoms are much the same when the lungs are the seat of the disease. In dead roupy fowls we have often found the higher bronchial tubes completely filled with solid cheesy matter, which prevented the air from passing into the lungs.

Occasionally cheesy matters are found in the folds of the pleura, and in other situations.

## The Course of the Disease.

The course of roup is usually of long duration. A simple, putrid discharge from the nose may stop in three or four weeks, and similarly false membranes may soon disappear; but generally the symptoms


Fig. 5.—Head of hen 35; eight days after infection with a culture of the roup bacillus—*a*, cheesy matter.

last for months. When the eyelids become swollen and tumours appear, the case is usually chronic. Affected birds may be better for a few days or weeks, and then become very weak again. Damp, cold weather usually intensifies the disease.

It is well known that fowls may be more or less sick from roup for one or even several years; and these birds should have the greatest care and attention, for they are generally the cause of new outbreaks. Once introduced, roup may remain in a flock for many years. The first cold and moist nights of the fall and early winter cause all kinds of catarrhs, which in many instances are followed by roup. Roup spreads rapidly in the winter time, and may attack from 10 to 90 per cent. of the fowls in a flock. Towards spring, the disease gradually disappears; during the summer months, a few birds remain chronically affected ; and then the first cold nights give the disease a fresh start.

Young fowls and fowls of the fine breeds are especially liable to roup. While some poultry men maintain that birds once having suffered from roup never take the disease again, most of the experimental evidence tends to show that no acquired immunity exists, as sometimes happens after other diseases. Some fowls are, however, naturally immune, and never take the disease. In the course of our own experiments, a white chicken which had never had roup, was inoculated with repeated and large doses of the roup germ, but without effect.


Fig 6.—Head of fowl 36; twenty-two days after inoculation with a culture of the roup bacillus—*a*, false membrane.

## The Cause of the Disease.

Many opinions have been expressed as to the cause of the disease ; and some of these have been based on scientific research, while others have been mere guesses. Some writers have thought that the disease is due to "Protozoa," a low form of animal life ; and others have isolated various bacteria from the disease tissues, which bacteria when grown in pure culture and introduced into healthy hens, have produced symptoms of the disease.

As roup, especially when located in the mouth or throat, resembles *human diphtheria*, it has been claimed that the well-known organism of this disease, the *Bacillus diphtheriae* of Klebs-Loeffler, is the cause of roup, or, as it is termed by some, "fowl diphtheria."

Statements have been made by European writers that outbreaks of diphtheria occurred in men, while at the same time poultry kept in the buildings in which the men lived were suffering from roup. They, however, do not state whether the roup commenced before the diphtheria or *vice versa*, and they give no good reasons for supposing that the outbreaks were actually connected with each other. In fact, we must state that the cases referred to, of alleged transmission of chicken diphtheria to man, are on examination found to be mere assumption, due to ignorance of veterinary pathology.

In 1898, several articles appeared in the Agricultural Press, written by H. A. Stevenson, M.D., who said, " Roup is caused by a specific germ, which appears to me to be identical with the Klebs-Loeffler bacillus," *i.e.*, the bacillus which causes human diphtheria ; and in another place, he says, " I believe roup and canker to be the same disease, a disease identical with diphtheria in man."

If the above statements were borne out by experiments, and found to be correct, we should have to demand the most rigorous treatment of diseased birds ; for Dr. Stevenson takes the position that diphtheria may be spread by roupy birds in exactly the same manner as tuberculosis is supposed to be spread by tubercular cattle.

These statements of Stevenson are, however, not based on careful experiments, and the *human* diphtheria antitoxin which he recommended as a sure cure for roup, has been found to be absolutely worthless for that purpose.

The following experiments and observations may be cited under this head :

A student of Professor Tresbot's devoured diphtheritic membrane from fowls without contracting the disease ; and Löffler, the discover of the human diphtheria germ, and Colin were never able to produce diphtheria in fowls by inoculation with human diphtheria germs. Gratia and Lieneaux treated roupy fowls with the human diphtheria antitoxin, and secured very poor results.

We have also ourselves made a large number of experiments with roupy fowls; and in about 300 roupy birds that have come under our observation, we have never been able to isolate the Klebs-Loeffler bacillus, *i. e.*, the bacillus of human diphtheria. Roupy fowls have also been again and again treated with diphtheria antitoxin without any result. Were the germs of human diphtheria and fowl diphtheria the same, the antitoxin would certainly have affected the diphtheria in the fowl, since it is the best known remedy for diphtheria in man.

Further, we find that the diphtheritic membranes in man and fowls are different. That of the former consists of a fibrinous exudation,—granular material, pus corpuscles, and débris of epithelial cells,—and contains the Klebs-Loeffler bacillus in great numbers ; and these can readily be stained by Gram's method.

The membrane from fowls consists almost entirely of pus cells, some granular masses, debris of epithelial cells (especially swollen nuclei of these), and bacteria; but amongst the bacteria, we seldom find one that can be stained by Gram's method.

Roupy fowls never show any of the symptoms caused by the bacterial toxin (poison secreted by bacteria,) which usually follow an infection with the true diphtheria bacillus.

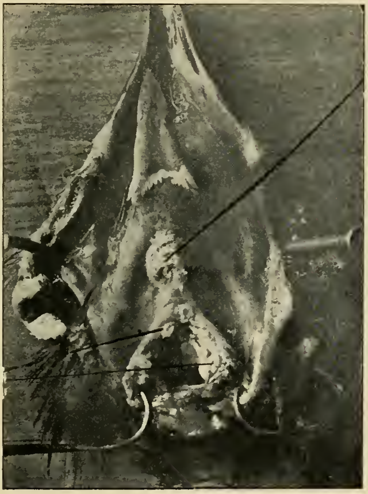



Fig. 7.—Fowl 46; throat and bottom of the mouth with false membrane (*m*), fourteen days after inoculation with B. pyocyaneus.

Hence we are bound to conclude, from the evidence here presented, and from other evidence we have at hand but which space alone prevents us from presenting, that *Stevenson's theory is untenable, and that fowl diphtheria is never caused by the human diphtheria germ,*— the Klebs-Loeffler bacillus.

## Results of Work at College.

In the present bulletin, only a brief summary of our work with roupy birds can be given. Any one wishing the full details of the exp rimental work may obtain them by writing to the College for the full report.

The first experiments were conducted, to find out *whether or not Roup was an infectious disease* ; and, for this purpose, 10 healthy fowls which had never been exposed to infection, were confined in a cage with diseased birds; and after varying periods of time, five of the healthy birds caught the disease. Fourteen healthy birds were then treated by rubbing a portion of the false membrane, or putrid nasal discharge from roupy birds, upon the normal, or slightly scratched, mucous membrane of the nose or eyes; and in this way, two birds were infected with typical roup.

These experiments, therefore, show the infectious nature of the disease; but the degree of infectiousness was not large. We must, however, remember that when fowls are kept under natural conditions where they are subject to cold, etc., the infectiousness may be much increased.

Having thus shown that roup is infectious, the next step was to isolate the causal micro-organism, a task of some difficulty, on account of the fact that the discharge from the nose, the false membrane, etc., is in close contact with, and likely to be contaminated by the air and food, which always contain large numbers of bacteria that fined suitable material and favorable temperature for growth in the albuminous secretions of fowl.

Very many bacteria were isolated, but when inoculated into healthy chickens, they proved to be harmless.

In other infections, such as Fowl Cholera, etc., it is comparatively easy to isolate the causal organism, because it is found in the blood and organs of the diseased fowl; but in roup we find that, as a rule, the organs and blood are free from bacteria, or else if bacteria are present, they are harmless.

Without giving the results of a long-continued series of fruitless examinations and experiments, made within the last four years, we may say that at length we have isolated a germ which causes roup, with all its varied symptoms. To this germ we have given the name *Bacillus cacosmus* (ill-smelling), and shall refer to it as the "roup bacillus." A technical description of the germ will be given in a more scientific paper at a later date.

Chronic diseases, of which we have an excellent example in roup, are notoriously hard to reproduce by the inoculation of healthy animals, because in most cases of sickness there must be, not only *the causal organism*, but a lowering of the vital forces; and, to get over the difficulty, we used pigeons, which are easily infected, to increase the virulence of the causal organism and thereby assist in the infection of hens. In this way, we produced roup in hens at pleasure by inoculation with the roup bacillus, taken from roupy pigeons.

The "roup bacillus" tends to penetrate the deeper layers of the mucous membrane or submucous tissues. Hence cultures made from swabs taken from the false membranes very rarely contain the "roup bacillus," because the bacilli are retained in the depths of the animal tissue.

The "roup bacillus" is especially difficult to isolate in cases in which the bird has had the disease for a long time, as the tumours and false membranes contain very many other kinds of bacteria in large numbers. In our experiments, even when roup was produced in healthy fowl by inoculation with pure cultures of the "roup bacillus," the mucous discharge from the very beginning contained many kinds bacteria.

The roup germs seem capable of remaining in a sort of dormant condition in the depths of the tissues for a long time,—so long that the fowls sometimes appear convalescent; suddenly, when the constitution is weakened by a cold or other causes, the roup germs become active and the roupy symptoms re-appear.

We have also found that roup, with all its varying symptoms, can be produced by the inoculation of healthy hens with the well-known

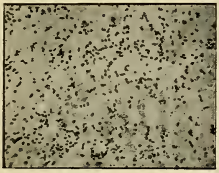
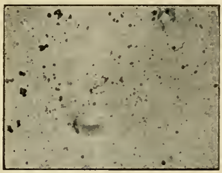


Fig. 8.—The Roup bacillus (B. cacosmus), from a twenty-four hour old agar culture.



Fig, 9—The Roup bacillus shewing the flagella (organs of locomotion). Van Ermegem's method.

*Bacillus pyocyaneus,* or green pus germ, which we have frequently isolated from roupy birds. Hence, it would seem that roup is simply a complex suppurative process; but, different from ordinary forms of suppuration, the pus in fowls appears in the form of a half or entirely solid, cheese-like, yellowish white mass, without any tendency to become soft or liquid, or to perforate the surrounding skin.

This may be proved by the injection of sterile turpentine (oil) into the eye-lids, which gives rise to inflammation and the formation of solid cheese-like matter in the depth of the tumour.

Therefore, the cheesy masses must be regarded as pus.

To sum up, roup, or fowl diphtheria, canker, etc., is a complex of suppurative processes, taking place especially in the head of fowls. This suppuration may be caused by different species of bacteria, and these may be very wide spread (e. g. Pyocyaneus), and thus an outbreak of roup may occur in a flock living in unsanitary conditions, without any previous introduction of the germs from elsewhere; but certainly this is the exception. More often, the disease is spread by sick fowls introduced into healthy flocks. Germs generally are spread throughout a yard by means of the secretions, although these do not always contain the casual organism. The infected fowls are not very much different in their general appearance and condition at the beginning of the disease, and thus they often take food and water for a long time, contaminating the food, troughs and cups. As the germs cannot infect fowls so long as the mucous membranes are intact and healthy, the disease does not spread for a certain length of time, although the germs may be present almost everywhere in the yard. Then comes a change of weather, such as a cold night or the beginning of fall and winter,—and suddenly the infectiousness of the disease is increased and roup spreads rapidly among the birds. Unfavorable weather, which causes colds and other infections of the mucous membranes, directly opens the way for infection. But it is possible that the roup bacilli, having infected a number of fowls, may gain so much in virulence as to be capable of entering into the tissues of the fowl without previous colds. Like colds, other circumstances which weaken the constitution of the fowls, such as unsuitable feed or feeding, unhygienic yards, bad water supply, etc., contribute towards the spread of the disease. Once present in a poultry yard, the roup-causing bacilli cannot be got rid of, unless by very careful disinfection ; and this is valueless so long as any of the fowls are diseased ; and, as we have already stated, fowls often remain affected with roup, carrying the germs in a semi-dormant state, for months or years.

It is possible that just one kind of bacillus, for example, our "roup bacillus," causes an outbreak of roup ; or an outbreak may be caused, as here at the Ontario Agricultural College, by several species.

### Treatment and Preventives.

As roup is not a specific infectious disease, that is, a disease caused by a single species of germ, it is almost impossible to prepare a preventive or curative serum. Hence this method of treating infectious diseases cannot be used in roup ; and besides it would be very costly.

The germs of roup are not very resistent ; they can easily be destroyed when present in cultures, or somewhere outside the animal ; but in the animal tissue, they are very difficult to kill, because they penetrate into the tissue ; and unless this too is killed, the germs continue living for a long time.

Roup may be cured by remedies, if the treatment is careful and judicious. Obstinately re-appearing false membranes can be successfully treated by burning the diseased tissue with a strong acid (hydrochloric acid 50 per cent. to 75 per cent.), or other caustics, such as silver nitrate. If the eyes and nose are attacked, they have to be carefully washed, at least twice a day, with an antiseptic solution, such as 2 per cent. boracic acid in a decoction of chamomile flowers, or

$\frac{1}{2}$ per cent. solution of corrosive sublimate. Thus the micro-organisms are killed or, at least, the diseased products which are discharged are removed, and the irritation caused by them; also the transformation into large cheesy masses is prevented.

We had chickens badly affected with roup of the eyes, which were cured with boracic acid and chamomile. On account of the smallness of the nostrils and nasal canals, it is very difficult to get the antiseptic solutions into the nose and nose cavities; but it can be done with a small syringe. If this treatment is too troublesome, then the nostrils, at least, should be washed and opened several times a day, to allow the secretions to pass away. We have treated chickens for 14 days by daily washing with a $2\frac{1}{2}$ per cent. solution of creolin and glycerine. After the washings, small plugs of cotton wool, filled with mixture, were placed in the nostrils and lachrymal ducts. This remedy did not cure the roup in the head, although the same mixture readily kills the roup bacillus in cultures in from 2 to 3 minutes. The greatest hindrance to a sure cure by remedies which have been used locally, is the ability of the germ to penetrate into the tissue and the many secondary cavities of the nostrils which cannot be reached by the antiseptics.

Fig. 10.—Showing method of treatment of roupy birds by immersion of the head in one to two per cent. solution of potassium permanganate.

Another method of treatment which gives excellent results, especially in the earlier stages of roup, is the use of a 1 to 2 per cent. of permanganate of potash. Fowls are treated in the following manner: the nostrils are pressed together between thumb and forefinger in the direction of the beak two or three times. Pressure should also be applied between nostrils and eyes in an upward direction. This massage helps to loosen the discharge in the nostrils and eyes. The bird's head is then plunged into the solution of permanganate of potash for twenty or thirty seconds, (see Fig. 10) in fact the head may be kept under the solution as long as the bird can tolerate it. The solution is thus distributed through the nostrils and other canals and has an astringent and slight disinfecting action. This treatment should be given twice a day and continued until all symptoms have disappeared.

If there are solid tumours in the eye-lids, they should be opened so that the skin may bleed freely. The cheesy matter should be removed, and the surrounding membrane touched with a 5 per cent. carbolic acid or silver nitrate solution, and then a cotton plug filled with some antiseptic solution, put into the cavity. The cavity has to be washed out daily with an antiseptic mixture, and a fresh cotton plug put in again to prevent the cavity from healing too quickly. We have cured chickens in this way in about a fortnight.

As all these methods of treatment demand a great deal of time and care, they cannot well be used for whole flocks, but the more valuable fowls may be treated in this manner. Farmers and poultrymen should first try the permanganate of potash method of treatment as it is the easiest to employ.

Food remedies influence roup only by strengthening the fowls and assisting nature to throw off or conquer the disease.

As in other infectious diseases, the most important thing is to prevent an outbreak, or to suppress it as soon as possible. All diseased fowls should be separated from the healthy ones ; and the healthy ones should be examined daily, with a view to isolate newly affected birds. After the isolation of the diseased birds, the poultry yard should be disinfected thoroughly with a 5 per cent. solution of carbolic acid, followed by a careful white-washing of the walls, etc. Slightly diseased fowls, or any of special value, can be cured, if much care be taken. Less valuable birds, which it will not pay to treat, should be killed as soon as manifest symptoms of the disease appear, especially when the face becomes swollen. These fowls, unless the best care is taken, will remain diseased for months, or perhaps years, and give rise to fresh outbreaks whenever an unfavorable season (with much wet, cold weather) occurs.

The most effective preventive for roup is to keep fowls in good sanitary conditions—in dry, roomy yards and dry, clean, airy houses which are free from draughts and can easily be cleaned and disinfected.

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# PEAS

AND THE

# PEA WEEVIL.

BY

C A. ZAVITZ, B.S A., Experimentalist,

AND

WM. LOCHHEAD, B.A., M.S., Professor of Biology

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# THE ONTARIO AGRICULTURAL COLLEGE

AND

# EXPERIMENTAL FARM

## GUELPH, ONT.

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HON. JOHN DRYDEN, Minister of Agriculture,
Toronto, Ont.

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## RECOMMENDATIONS.

The results reported in this bulletin of experiments conducted at the Ontario Agricultural College in growing peas and in combating the pea weevil, as well as the information obtained from some of the most extensive growers, merchants, millers, and exporters of peas in Ontario, lead us to make the following recommendations :

(1) That the acreage of both field and garden peas of the very best varieties be greatly increased in those sections of the Province where there are no pea weevils ;

(2) That the growing of both field and garden peas (to be ripened) in the weevil-infested districts of Ontario be discontinued for the next two years, and such crops as Early Yellow Soy beans, Grass peas, Emmer (improperly called Spelt), mixed grains, etc., be substituted ;

(3) That if any persons continue to grow and ripen peas in the infested districts, they make the best possible use of the fumigation method ;

(4) That seedsmen, farmers, and others send no infested peas into those districts of Ontario where the pea weevil does not exist ; and

(5) That farmers, gardeners, seedsmen, millers, exporters, importers, and all others who have anything to do with the growing or handling of peas in Ontario, co-operate heartily in the effort to eradicate the pea weevil from Ontario within the next two years.

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# PEAS AND THE PEA WEEVIL.

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The field pea (*Pisum arvense*) is a native of Italy and has been grown in the East from time immemorial. The garden pea (*Pisum sativum*) is regarded by some botanists as a cultivated variety of the field pea. Both kinds have been extensively grown in Ontario for many years, and have been highly prized for their intrinsic value.

## Different Uses of the Pea Crop.

Peas are used in, perhaps, a greater variety of ways than any other crop grown in this Province. They are most commonly sown alone, but not unfrequently in conjunction with oats, barley or spring wheat. The crop is occasionally pastured off the land by farm stock, and it is sometimes plowed under to increase the fertility of the soil. When harvested, the unthreshed pea crop may be used as green fodder, or cured and fed in the form of hay. The ripened peas are used extensively for feeding farm stock, or are sold for seed purposes in the foreign as well as in the home markets. Shelled peas, when either green or ripe, are prepared and used in various ways for culinary purposes. The straw of green peas is hauled from the canning factories and fed at once, or placed in the silo, or made into hay; and the straw of the ripened crop is used throughout the winter season for feeding sheep, dairy cattle, and other farm animals.

## Pea Growing in Ontario.

The pea crop has undoubtedly occupied a very important place in the agriculture of Ontario. According to the reports of the Bureau of Industries, the average market value of the threshed peas grown in Ontario during the past twenty years amounted to fully eight million dollars a year. In 1897, no less than 896,735 acres were devoted to the pea crop, this being the largest area under peas in any single year. Since that date, however, there has been a gradual decrease until the year 1902, when only 532,639 acres of peas were grown. This decrease is undoubtedly due to the great damage done to the crop in south-western Ontario by the pea weevil, commonly known as the " pea bug."

## Insect Enemies of the Pea Crop.

Pea Weevil. Scientifically, the pea-weevil is known as *Bruchus pisorum*, a name given to it by the celebrated Linnæus, who first described the insect sent to him from America. Although called a weevil, its snout is very short; hence, it is not a true snout-weevil.

The adult beetle is scarcely more than one-fifth of an inch in length, and one-tenth of an inch in width. As to color, it is brownish-black, with white and black markings, arranged as in Fig. 1, *d*. Besides the white markings, there are two black spots on the end of its body, which the wings do not cover. When examined closely with a good magnifying glass, the feelers are found to be composed of eleven joints, the sides of the thorax are notched, and the thighs of the hind legs are thickened and provided with two spines.

The beetles make their escape from the peas either in the late summer or spring; the majority probably in the spring. Those that appear in the fall, pass the winter in the barn or under fences or rubbish, or possibly in the ground. When the peas are in blossom, the beetles appear on the vines, and the female deposits her yellow, spindle-shaped eggs on the outside of the young pods. Many eggs are frequently found on a pod, but always singly, and attached by a sticky substance, which becomes white and glistening when dry.

In a few days, the grub hatches from the egg, bores through the wall of the pod, and enters the nearest pea. Within the seed it feeds and grows.

The grub (Fig. 1, a) is maggot-like, being fleshy, slightly swollen in the middle, and white, with the exception of its mouth, which is brown. It has three pairs of minute legs, which are frequently overlooked. When full grown, it is about one-fourth of an inch long. It eats a a circular hole on the side of the pea, leaving only a thin hull as a covering. It then lines this cavity with a thin paste, within which it changes to a pupa.

The pupa (Fig. 1, b and c) is white, but often becomes brown after the peas are threshed and fumigated. The pupal stage is the resting one, and lasts about a week, the exact duration depending largely on weather conditions. It then transforms into an adult beetle, which may either emerge from the pea immediately or remain passive within its cell, even until late in the spring.

Pea Moth. This pea enemy, known as the pea moth, (*Semasia nigricana*) is more widely distributed in Canada than the pea-weevil, but it does not work so much injury. This tiny moth (Fig. 2, b and c) is the parent of the small caterpillars, or "worms," which are often found within the pod on the surface of partly eaten and web-covered peas. Besides inflicting injuries to the peas, these "worms" (Fig. 2, a) leave much excrementitious matter in the form of pellets, which render the seeds disgusting and worthless. When nearly full grown, the caterpillars go into the ground, where they spin a fine cocoon, and remain all winter. In July, the moths emerge, and begin egg-laying a few only being laid on the young pods. The young caterpillars hatch from the eggs in about two weeks.

Late peas are injured most, and sometimes these are badly damaged. (Fig. 2, d). No reliable treatment has as yet been found to control them, but it is advisable to sow early peas, since these are least injured.

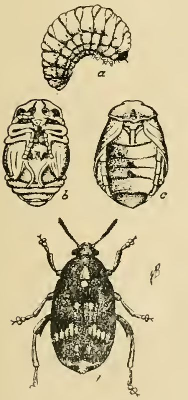



Fig. 1. *Pea Weevil.*—(*a*) The grub; (*b*) the pupa, under surface; (*c*) the pupa, upper surface; (*d*) the adult weevil. (Original.)

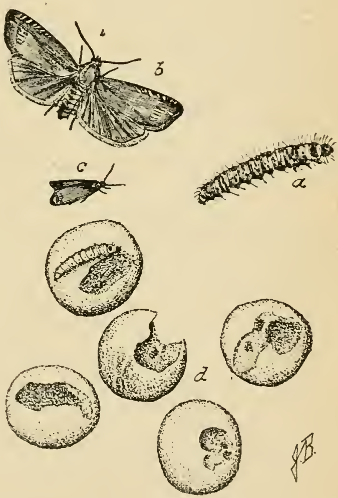



Fig. 2. *Pea Moth.*—(*a*) A full grown "worm" or caterpillar (enlarged); (*b*) adult moth with wings expanded (enlarged); (*c*) adult moth with wings closed; (*d*) a group of five peas injured by the caterpillar of the pea moth.

Pea Aphis. Within the past few years, the pea aphis, (*Nectarophora pisi*) appeared in several localities in Ontario, especially in Prince Edward, Lennox, Addington, and Wentworth, where it caused considerable loss. In many of the States to the south of us, the losses from this insect were very large. The life history of the "aphis" is interesting, as it spends the first part of the season on clover, migrates to peas in summer, moves back to the clover in the fall, and upon it spends the winter. In Ontario, however, it has done no serious harm to the clover crop. Fortunately it is attacked by several predaceous and parasitic insects, and by a fungus, all of which aid in keeping it in check.

## THE HISTORY OF THE PEA WEEVIL IN ONTARIO.

Until recently it was the general belief that the pea weevil was a native of America; but there is a strong reason in favor of its foreign origin. It is not known to feed on any other plant than the cultivated pea, of the genus *Pisum*, which is an introduced plant of Eastern origin. It is likely, therefore, that it came from the East, whence came so many of our cultivated plants, and their insect enemies as well.

The earliest published record of the depredations of the pea weevil in Ontario, so far as we are aware, is that made by the Rev. Geo. S. J. Hill of Markham, in 1857. This gentleman won the second prize (£25) offered by the Legislature of Canada, for an essay on the insects injurious to the wheat crop. Incidentally, in that essay, allusion was made to the pea weevil, which was stated to be one of the most injurious insects to the farm. It is very probable, then, that the weevil even in the fifties was an old offender.

About 1860, the weevil was very injurious in Wentworth county. It is stated that the farmers, almost to a man, at that time gave up growing of peas for two years with the result that the weevil was destroyed. The south-western counties have nearly always suffered most severely; for frequently when the remaining portions of the Province have been entirely free from the pest, the pea crops in the south-western counties have been badly injured.

Rev. Dr. Bethume, editor of the *Canadian Entomologist*, writes us that the weevil has been a familiar insect to him for nearly forty years, and that while he was editor of the entomological column of the "Canadian Farmer," published by the late Hon. George Brown, from 1865 to 1873, he frequently had occasion to give correspondents information regarding the insect. During this whole period of nine years, the weevil was very injurious, especially in the south-western part. In 1870-71, few peas were grown in Essex, Kent, and Lambton, while good crops were common and the weevil was not abundant in the neighborhood of London. Gradually, however, and year by year, the weevil spread north-eastward; and about 1878-1880 most of the farmers in that part of the Province, south of a line drawn from Newmarket to Goderich, were compelled to give up, to a laıge extent, the growing of peas.

During the years 1885, '86, '87, the weevil did very little injury. The acreage devoted to the pea crop in south-western Ontario was gradually reduced during 1882, '83, and '84, and this may account for the partial disappearance of the weevil during the following years. (Fig 3, c) A few farmers, however, neither stopped growing peas nor fumigated their infested crops; and this was a great mistake, as it prevented a general eradication of the weevil. Along with the in-

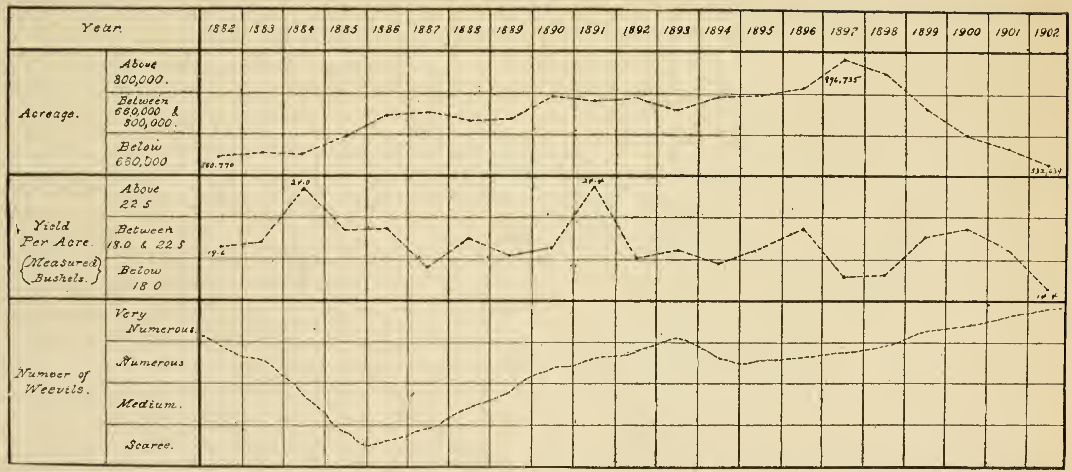



Fig. 3. Diagrams to show the increase or decrease in Ontario of (*a*) the acreage of peas, (*b*) the yield per acre, and (*c*) the number of pea-weevils for the last twenty-one years (1882 to 1902), based principally on the reports of the Bureau of Industries. (Original.)

crease of the acreage from 1886-1890, the weevil increased in numbers and spread rapidly along the Lake Ontario counties to the great pea-growing sections of Prince Edward and Lennox and Addington. During 1892-1893, the weevils were very numerous, but during 1894-1895 there was another decrease in the extent of the injury done. From 1896 until the present, the pest has been on the increase and many sections have given up the growing of peas. Durham, Northumberland and Prince Edward, some years ago, grew large quantities of seed for French and American seedsmen; but the depredations of the weevil became so serious that the growing of peas has, to a large extent, been discontinued in these counties.

There is a larger section of the Province, however, which is free from the weevil. (See Fig. 4.) A line drawn from Brockville to Midland separates the weevil area from the area which is practically free from the weevil. This more northern area includes such fine farming districts as the Ottawa Valley, the Temiscaming district, Parry Sound, Southern Algoma, the Manitoulin and St. Joseph Islands, and the Fort William and the Rainy River districts. This northern area could grow sufficient peas for home consumption, and for our foreign markets, until the pea weevil is eradicated in southwestern Ontario.

## LOSS TO ONTARIO IN 1902 BY THE PEA WEEVIL.

It is always a difficult problem to estimate correctly the losses caused by an injurious insect, as several factors of uncertain value must be considered. In the case of the pea weevil, the factors are:

(1) *The Decrease in Acreage.* (Fig. 3). This in itself should not be considered a total loss; for if the land is not sown to peas, it is not lying idle, but is used for the production of some other (often substitute) crop. When we study the statistics of the pea crop of Ontario for the last twenty years (since 1882), we are forced to conclude that the acreage of peas in 1902 is just about one-half of what it would have been if the weevil had not proved destructive. In 1882, the total acreage of peas was 560,770 acres; in 1885, 646,081 acres; in 1888, 696,653 acres; in 1891, 752,453 acres; in 1894, 785,007 acres; in 1896, 829,601 acres; in 1897, 896,735 acres; in 1898, 865,-951 acres; in 1899, 743,139 acres; in 1900, 661,592 acres; in 1901, 602,724 acres; and in 1902, 532,639 acres. There was, therefore, a gradual increase from 1882 up to 1897, then a gradual decrease from 1897 to 1902. That this decrease in acreage was due to the pea weevil there can be but little doubt. If we suppose that the area devoted to the pea crop in 1902 should have been about one million acres, according to the natural rate of increase from 1882 to 1897, then there is a decrease of about 500,000 acres in 1902. The decrease in yield would be about 10,000,000 bushels, worth about $6,000,000.

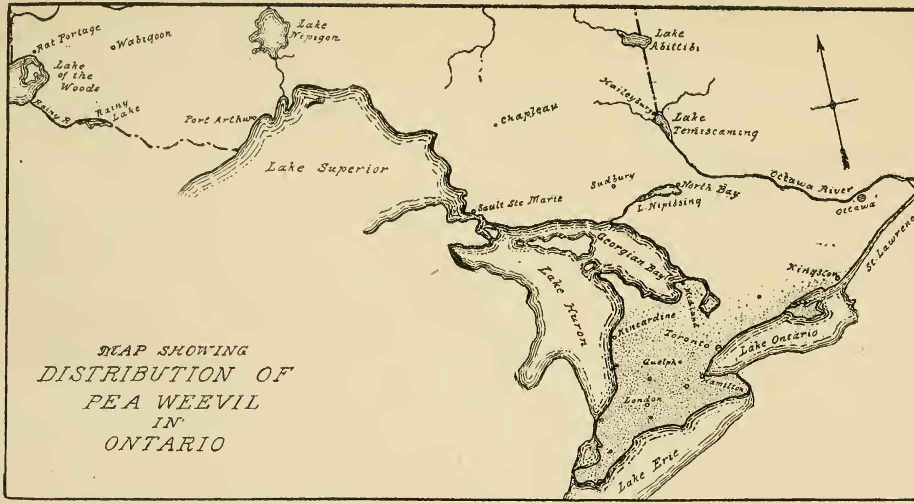



Fig. 4. Infested areas are dotted, the closer the dots the more prevalent the weevil. This map is based principally on reports on Co-operative Experiments throughout Ontario in 1901 and 1902, and by a correspondence carried on in 1902 by the Ontario Bureau of Industries, Toronto. (Original.)

(2) *The Decrease in Yield per Acre.* In a season like that of 1902, when all kinds of pea crops were partial failures, it is difficult to estimate correctly the loss due to the weevil alone. The average yield of peas for the past year was about five bushels per acre less than the average yield for the past twenty years; and it should be understood that the returns sent to the Bureau of Industries are given in measured bushels and not in weighed bushels of 60 pounds.

(3) *The Decreased Market Value of Weevilly Peas.* This is very marked in the south-western part of Ontario where the weevils have done so much injury for a number of years past. As there are large areas in Northern Ontario, however, where peas of excellent quality and free from weevil are still grown, Ontario's reputation as a producer of seed peas of high quality should be maintained. More than half of the territory of Ontario is practically free from the weevil; and with care, our foreign trade in seed peas of superior quality should be increased rather than diminished.

(4) *The Decreased Value of Weevilly Peas for Feeding Purposes.* As a result of a number of examinations, it is found that where weevils have infested all the peas and have afterwards escaped, the seed weighs on an average about 45 pounds instead of 60 pounds per measured bushel, or in other words, the weevils have eaten one-quarter of the peas. In the case of the small peas, such as the Chancellor variety, the injured seed weighed only 37.7 pounds per measured bushel; and in the case of the large peas, such as the Black-Eyed Marrowfat and the New Canadian Beauty, the injured peas weighed from 48 to 52 pounds per measured bushel.

(5). *The Small Germinating Power of Weevilly Peas when Used for Seed.* On an average, only about 30 per cent. of the weevilly peas will germinate. Farmers, however, try to secure sound peas, or use an increased quantity of weevily peas for seed purposes.

The average annual yield of peas per acre for twenty years (1883-1902) is 19.3 bushels, while for the last five years (1898-1902) it is 17.6 bushels. This gives a decrease of 1.7 bushels per acre; and with an area of 532,639 acres in peas in 1902, it represents a loss of over 900,000 bushels, worth over half a million dollars. These amounts do not represent the actual loss in yield, due to the weevil; they simply mean that the loss in 1902 was $500,000 more than it would have been on the same acreage during an average year of the twenty; but the weevil was more or less injurious during all of these years; so the real loss in 1902 due to decrease in yield per acre, would probably be upwards of $1,000,000.

If we group the losses due to the last three factors. we may get a rough estimate, by supposing that one-quarter of all the peas produced in 1902 was destroyed by the weevil and hence made less marketable, less valuable for feeding, and less germinable. The total yield in 1902 was 7,664,679 bushels, worth in round numbers only

$3,000,000, instead of $4,000,000, a loss of $1,000,000. There is, therefore, a total direct loss of over $2,000,000.

In dealing with the probable losses by the weevil we have been very conservative in our estimates. For example, we have attempted to estimate the loss occasioned by the decrease in acreage ; but unless the best substitutes for the pea crop are grown, persons engaged in the bacon industry, or the export trade, will be disposed to believe that Ontario suffers a heavy loss in this great decrease.

## VARIETIES OF FIELD PEAS.

Upwards of one hundred varieties of peas have been grown in our experimental grounds within the past fourteen years. The greater number of these have been tested for at least five years in succession, after which time the poorer varieties have been dropped and the more valuable kinds have been retained in the experiment.

| Varieties. | Color of peas. | Average results for seven (7) years. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Weight of 1,000 sound peas. (2 years.) | Time between seeding and ripening. | Length of vines. (5 years.) | Peas containing weevil. | Weight per measured bushel. | Yield per acre. | |
| | | | | | | | Straw | Peas. |
| | | Oz. | Days. | Inch's | p.c. | Lbs. | Tons. | bush. 60 lbs. |
| 1. White Wonder ............ | White... | 9.5 | 97 | 19 | 34 | 60.4 | 1.2 | 38.2 |
| 2. New Zealand Field ........ | White.... | 7.3 | 100 | 36 | 40 | 58.5 | 1.3 | 37.0 |
| 3. Early Britain.............. | Brown ... | 10.3 | 100 | 39 | 39 | 57.8 | 1.4 | 36.5 |
| 4. Egyptian Mummy ......... | White.... | 9.1 | 101 | 31 | 25 | 62.5 | 1.6 | 35.3 |
| 5. Tall White Marrowfat ..... | White.... | 9.2 | 101 | 41 | 38 | 59.6 | 1.6 | 34.7 |
| 6. New Zealand Brown ....... | Brown . . | 10.0 | 102 | 39 | 38 | 56.8 | 1.5 | 34.4 |
| 7. Potter..................... | White. .. | 8.9 | 101 | 43 | 37 | 59.5 | 1.5 | 33.4 |
| 8. New Zealand Blue . ....... | Blue ..... | 8.9 | 99 | 23 | 36 | 59 7 | 1.1 | 32.9 |
| 9. Prussian Blue.... .. .. | Blue ..... | 7.1 | 105 | 47 | 34 | 60 0 | 1.7 | 31.8 |
| 10. D'Auvergne ............... | White.... | 7.4 | 96 | 40 | 38 | 59.1 | 1.3 | 31.3 |
| 11. White Eyed Marrowfat .... | White.... | 8.6 | 103 | 41 | 35 | 60.4 | 1.5 | 31.2 |
| 12. Common Grey ........... . | Brown ... | 9.8 | 101 | 40 | 34 | 56.5 | 1.5 | 30.7 |
| 13. New Canadian Beauty ..... | White.... | 10 7 | 101 | 45 | 35 | 60.3 | 1.4 | 30.5 |
| 14. Chancellor............ .... | White.... | 5.1 | 94 | 40 | 36 | 58 5 | 1.3 | 30.5 |
| 15. White Imperial........... | White. .. | 9.2 | 101 | 41 | 35 | 59.3 | 1.4 | 30.2 |
| 16. Improved Grey ........... | Brown ... | 10.3 | 100 | 39 | 49 | 56.9 | 1 4 | 30.2 |
| 17. Canada Cluster .... ....... | White.... | 8.9 | 101 | 39 | 29 | 61.0 | 1.5 | 29.3 |
| 18. Crown..... ............. | White.... | 6.9 | 100 | 42 | 41 | 58.0 | 1.4 | 28.9 |
| 19. Black Eyed Marrowfat..... | White.... | 10 3 | 102 | 39 | 39 | 59.5 | 1.4 | 27.1 |
| 20. Golden Vine........... . | White.... | 5.2 | 102 | 41 | 33 | 59 8 | 1.4 | 27.1 |
| 21. Sword ..................... | White... | 5.4 | 104 | 47 | 33 | 59.6 | 1.6 | 27.1 |
| 22. Centennial White.......... | White.... | 8 1 | 104 | 49 | 32 | 60.4 | 1.5 | 26.9 |
| 23. Multipliers ................ | White.... | 6.9 | 105 | 50 | 32 | 60.5 | 1.8 | 26.0 |
| 24. Prince Albert............. | White.... | 6.4 | 109 | 52 | 31 | 60.9 | 1.7 | 25.1 |
| 25. Striped Wisconsin Blue..... | M'tl'd blue | 7.1 | 106 | 46 | 32 | 61.2 | 1 8 | 25.0 |
| 26. Coffee ..................... | D'k brown | 11.8 | 102 | 44 | 34 | 57.8 | 1 5 | 23.5 |
| | | 8.4 | 101 | 41 | 35 | 59.4 | 1.5 | 30.6 |

Careful tests have been made each year, to determine the productiveness, the quality, the resistance of the attacks of the pea weevil, etc., of all the varieties under experiment. The table here presented gives the average results of each of twenty-six of the leading varieties for a period of seven years.

It will be observed from the average results given in the table that there is a great variation in the comparative size of the peas. One thousand seeds of the New Canadian Beauty weighed 10.7 ounces, and a similar number of the Common Golden Vine variety weighed only 5.2 ounces, the weight of the former being more than double that of the latter.

The average number of days between the time of seeding and the time of ripening of all the varieties for the seven years is 101. It will be observed, however, that the Chancellor variety matured in 94 days after planting, and that the Prince Albert required 109 days to reach maturity. There was thus an average of fifteen days between the dates on which the earliest and the latest varieties reached their ripened stage.

In the average length of vines there is a great difference, the extremes being 19 inches for the White Wonder, and 52 inches for the Prince Albert variety. Owing to the extreme shortness of the straw of the White Wonder peas, they are suitable only for very rich soil which naturally grows an abundance of straw. The Golden Vine variety produces a straw which is exactly the same length as the average of all the varieties included in this report.

In each of the past seven years, very careful notes have been taken regarding the average percentage of peas of each variety which were infested with the pea weevil. In order to obtain this information, two hundred peas of each variety were opened on each examination, and the number of weevilly peas was carefully counted. It will be seen from the figures given in the table, that all of the varieties were more or less affected. Those varieties having the smallest percentage of weevilly peas in the average of the seven years' experiments were the Egyptian Mummy, 25 per cent., and the Canada Cluster, 29 per cent. The Egyptian Mummy and the Canada Cluster are varieties very similar in their habits of growth. Those varieties having the greatest number of weevilly peas were the Improved Grey, 49 per cent.; Crown, 41 per cent.; and New Zealand Field, 40 per cent. Of all the peas grown from the twenty-six varieties during a period of seven years, 35 per cent. were weevilly.

Although all the varieties of the peas grown and harvested in the Experimental Department for seven years have been submitted to the carbon bisulphide treatment, and no live weevils have been sown with the peas during that length of time, yet the percentage of weevilly peas in the resulting crops has steadily increased from year to year. The increased amount of damage done by the weevil to the pea crop for seven years is represented by the following proportions of peas infested with the weevil: 1894, 4 per cent.; 1895, 8 per cent.; 1896, 12 per cent.; 1897, 26 per cent.; 1898, 39 per cent.; 1900, 65 per cent.; and 1901, 89 per cent. While we have been very careful to treat the peas immediately after harvest, some of the neighboring farmers have continued to grow peas, and have not fumigated the crops; hence the marked increase in the number of weevilly peas from year to year. The fact that the percentage of weevilly peas has increased in this district from less than 10 per cent. to practically 90 per cent. in a period of six or seven years indicates what is likely to occur in those districts of Ontario where the pea weevil is just getting a hold, providing no precaution is taken to eradicate it, either by fumigation or starvation. Neither in the Experimental nor the Farm Department of the College were any peas sown in the spring and allowed to ripen in the summer of the present year.

The average weight per measured bushel of all the varieties given in the table is 59.4 pounds. These results have been influenced more or less by the damage done by the weevil; but as the peas were treated immediately after harvest, they weighed heavier than if the weevils had been allowed to complete their work and escape from the peas. As a result of careful examinations which we have made of peas, all of which had been infested and from which the weevils had escaped, we found the weight per measured bushel varied from 38 to 52 pounds according, largely, to the size of the peas; the smaller the peas, the greater the amount of damage done by the weevils.

It will be seen that the average amount of straw produced by the different varieties varied from 1.1 to 1.8 tons per acre. For the average soil of Ontario, those varieties which produce a medium to a large amount of straw, usually give the best satisfaction.

There is, perhaps, no result of the varieties here presented which is more striking than the yield of peas per acre, the highest being 38.2 and the lowest 23.5 bushels. It must be remembered, however, that the White Wonder variety, which stands at the head of the list in yield of peas, is not suitable for the majority of Ontario farms, owing to its short growth of straw. The Egyptian Mummy variety produces a large yield of both seed and straw, but the straw is coarser than that of most other varieties. It will also be remembered that the individual peas of this variety are quite large in size, and that the percentage of weevilly peas was less than that of any other variety.

Within the past nine years, ten varieties of field peas which have given good results in the trial grounds at the college, have been distributed throughout Ontario for co-operative experiments. These experiments have been successfully conducted on five hundred and seventy-one Ontario farms. Those varieties which have given the largest average yield of grain per acre, each producing upwards of 25 bushels, are the Egyptian Mummy, Chancellor, Prussian Blue, and Striped Wisconsin Blue; and those varieties which have given an average yield of between 24 and 25 bushels per acre are the Early Britain, the Canadian Beauty, and the Canada Cluster.

Each experimenter has been asked to examine the peas carefully for the weevil by splitting open 200 peas from each plot and counting the number of weevils in the form of either little white worms or darkish brown beetles.

From the reports received, we find that, with the exception of a very few scattered places, there is no pea weevil north and east of a line drawn from Brockville to Midland. The accompanying map (page 9) shows the distribution of the insect throughout Ontario, based largely on the reports of our co-operative experimenters for the past two years (1901 and 1902). Reports have been received from all of the districts in New Ontario, and indicate something of the great possibilities of that country in supplying peas of superior quality until the pea weevil can be eradicated from south-western Ontario.

## Selection of Seed.

Large and Small Seed. An experiment has been conducted for five years in succession to ascertain the relative value for seed purposes of large and small peas of the same variety. In each of five years, a certain number of large sound peas were carefully selected and counted. A similar number of small sound peas were selected at the same time and from the same variety. The small peas were usually about one-half the size of the large ones In each year, both lots were sown at the same time and on uniform plots of equal size, situated side by side.

The average results for the five years were as follows: Yield of the large seed, 30.3 bushels of grain and 1.3 tons of straw per acre, and that of the small seed, 23.9 bushels of grain and 1.1 tons of straw per acre. A certain number of large peas, therefore, gave 26.8 per cent. more grain, and 18.2 per cent. more straw than a similar number of small peas of the same variety in the average of five years' experiments.

Whole and Split Seed. Many farmers thresh their peas with a grain separator and part of the peas are split in the process of threshing. Some farmers carefully separate the split peas and sow nothing but whole seed; while others sow their peas without making this separation. An experiment has been conducted at the college for eight years in succession by sowing on uniform plots equal quantities of whole and split seed of the same variety. The average results for the eight years were,—the whole seed, 30.7 bushels of grain and 14 tons of straw per acre, and the split seed, only 10 bushels of grain and 3-5 of a ton of straw per acre.

SOUND AND WEEVILLY SEED. Many observers have noticed frequently that the weevil is not full grown when the peas are harvested, and has not eaten much of the substance of the pea. We have also observed this fact; but very frequently we have observed that the grub is full grown and in the pupa or the imago state, and has done practically all the harm that it is capable of doing.

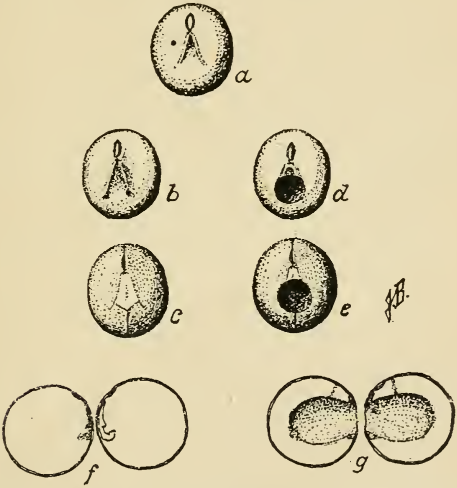



Fig. 5. (*a*) An infested pea showing the spot where the weevil entered ; (*b*) a pea not infested, with " skin" on ; (*c*) same as (*b*) but with " skin" removed ; (*d*) an infested pea showing how the germ is often destroyed by the weevil, " skin" on ; (*e*) same as (*d*) but " skin" removed ; (*f*) an uninfested pea opened up into halves showing the germ ; (*g*) an injured pea opened up, showing how the weevil often destroys both the food and the germ. (Original.)

When the grub is not full grown, the fumigation of the peas will preserve them from further injury ; but when the weevil has reached the pupa stage, it has done all the injury of which it is capable.

It is frequently stated that the grub, when working in the pea, avoids the germ or embryo, and that peas which are bored with the weevil are as valuable for seed as those which are not thus injured. Such statements are wholly incorrect. On examining many hundreds of " weevilly " peas at various times, we have found that the great majority of the seeds have their germs completely destroyed, and that the grubs show no inclination whatever to avoid the germs. (Fig. 5). Moreover, germination tests, carried out on several occasions with injured seeds, have proved conclusively that but a small percentage of them germinate, and a still smaller percentage develop into vigorous plants. In 1897, we found that about three-fifths of the peas of the Marrowfat variety, which had been injured, did not germinate, and that with the Golden Vine variety only thirteen per cent of the peas germinated. If a person were sowing weevily seed of the Golden Vine variety, it would be necessary to sow 15 acres of peas in order to get as many plants as would be produced from sowing two acres with sound seed.

The material has been stored within the seed by the plant for a purpose, and that is, to serve as a food supply for the germinating plantlet. Not until the plantlet has developed both a root system and a leaf system can it prepare food for itself. Up to this period it is entirely dependent on the food stored up in the seed; and it is plain that seeds which have a large portion of their food eaten by the weevil will stand but a poor chance of producing good plants.

## Dates of Seeding.

Peas were sown in our experimental plots on six different dates, in the spring of each of six years previous to 1901. One week was allowed between each two seedings. In the average of the six years, the first seeding took place on April 18th, and the last seeding on May 23rd. The average of grain per acre from the six different seedings was as follows:—1st seeding, 26.5 bus.; 2nd seeding, 30.1 bus.; 3rd seeding, 28.8 bus.; 4th seeding 25.5 bus.; 5th seeding, 21.5 bus.; 6th seeding, 19.5 bus. The peas from the different seedings were examined, and it was found that as the season advanced, the percentage of peas containing weevils decreased slightly. In order to get more complete information on this subject, peas were distributed for co-operate experiments throughout Ontario in 1899 and again in 1900, and were sown on four different dates with two weeks between each two seedings. The first seeding took place in the latter part of April and the last seeding in the early part of June. The following are the average results of the various tests made over Ontario for two years:—

| Seeding. | Per cent. of Weevilly Peas. | Bushels of Peas per Acre. |
|---|---|---|
| 1st Seeding | 79 | 21 |
| 2nd Seeding | 67 | 17 |
| 3rd Seeding | 57 | 13 |
| 4th Seeding | 41 | 9 |

It will be seen that the decrease in the yield of grain per acre is more marked than the decrease in the percentage of weevilly peas.

### Seed per Acre.

There is a great difference in the comparative size of the peas of different varieties and also a considerable difference in the character of growth of the plants of the various kinds. It is impossible, therefore, to state any definite amount of seed which will always give the best results with all varieties. While we have obtained excellent results from sowing 2 bushels of the Golden Vine, Chancellor, and Sword peas per acre, which are small seeded varieties, we have found that it is necessary to sow 3½ bushels per acre of the large seeded varieties, such as, the Black-eyed Marrowfat, and New Canadian Beauty, if we wish to get equally good returns.

### Methods of Sowing.

Thirty experiments have been made, comparing the results of sowing peas broadcast and with a grain drill. The land has been in a good state of cultivation in every instance. A spring tooth cultivator, which slightly ridges the land, has generally been used immediately before sowing. The average results of the thirty experiments, show that the land on which the seed has been sown with a grain drill, has produced one and one-third bushels per acre more than the land on which the peas have been sown broadcast.

### Growing Peas with Other Crops.

Mixtures for Green Fodder and for Hay. For six years in succession, peas, oats, barley, and spring wheat were sown separately and in eleven different combinations, for the purpose of ascertaining whether or not better results could be obtained from growing certain crops together than by growing the same crops separately; and also of finding out which mixtures would give the best results for green fodder and for hay. It was found that in fully 90 per cent. of the experiments, the grains which were grown in mixtures gave a larger yield of both green fodder and hay per acre than the same grains sown separately. In the average results of six years' experiments with eleven different mixtures, the greatest yield was obtained from a mixture of peas and oats.

In another experiment conducted for six years, in which nine different proportions of peas and oats were used, it was found that the most satisfactory results were obtained from a mixture of two bushels of oats and one bushel of peas, or a total of three bushels of seed per acre.

Among all the different varieties of peas and oats which have been grown at the College, a few of the most suitable kinds have been selected and grown in combination in order to find out which varieties give the best results for fodder purposes. In an experiment which has been conducted for five years in growing three different mixtures of peas and oats, comprising early, medium, and late varieties, we get the following results in length of time required to produce fodder of the best quality, and in yield of green fodder per acre: Daubeney oats and Chancellor peas, 70 days, 5.9 tons; Siberian oats and Prussian blue peas, 77 days, 6.9 tons; and Golden Giant oats and Prince peas, 84 days, 6.1 tons. The *Siberian oats and the Prussian Blue peas* form a mixture which has given the best general satisfaction of all the varieties grown together for fodder. By sowing this mixture at different dates in the spring, the time in which the fodder can be used to good advantage can be considerably extended.

Co-operative experiments were conducted over Ontario for five years in succession to test the value of peas and oats (2 of oats and 1 of peas) as compared with tares and oats (2 of oats and 1 of tares) for green fodder. The average yield of green fodder from each acre per annum was 7.9 tons from the former, and 8.2 tons from the latter. It will, therefore, be seen that the mixture of tares and oats surpassed the mixture of peas and oats by an average annual yield of 600 pounds of green fodder per acre.

In those districts of Ontario where the pea weevil does not exist, peas and oats can be grown together satisfactorily for the production of either green or dry fodder. In those portions of the Province where the pea weevil is troublesome, spring tares may be used instead of peas to mix with oats. If, however, peas and oats are grown together for green fodder in the weevil-infested districts, the crops should be cut about the time that the peas have reached the blossoming stage.

Mixtures for the Production of Grain. In the trial grounds at the College, peas, oats, barley and spring wheat were grown separately and in eleven different combinations for the production of grain. This experiment was conducted in duplicate for six years. A mixture of oats and barley gave the greatest yield (2,261 lbs.) of grain per acre; a mixture of oats, barley and peas gave the second highest yield (2,101 lbs.) of grain per acre; aad a mixture of oats and peas gave the fifth highest yield of grain (1,988 lbs.) per acre.

On examining the peas which were grown with the oats, wheat, and barley, we found weevils; but the percentage of weevil was not quite so high as where the peas were grown by themselves.

## Peas as a Pasture Crop.

In 1900 and again in 1901, we tested oats and peas, both separately and in combination, for pasture purposes. When the crops were about twelve inches high they were pastured off by cattle. That the green oats were eaten more readily than the green peas was quite noticeable. These crops did not prove very satisfactory as cattle pastures. From observations made we believe that a mixture of oats and peas would perhaps make a suitable pasture for sheep, and that either peas alone or a mixture of peas and oats would furnish a good pasture for swine.

## Peas as a Green Manure.

An experiment was conducted in different parts of the experimental grounds for four different years, to ascertain the relative value of peas, buckwheat and rape for plowing under as green manure for fall wheat. These crops were sown at such times that they would reach the best condition for plowing under by the end of July. After the crops were plowed down each year, the land was cultivated on the surface three or four times during the month of August and the wheat was sown on or about the first day of September.

As the result of four experiments, the average yield of wheat per acre per annum was 36.1 bushels on the pea land, 30.4 bushels on the rape land, and 29.6 on the buckwheat land. It will, therefore, be seen, that the land on which field peas were used as a green manure produced 6½ bushels per acre more than similar land on which buckwheat was used for plowing under.

## Substitutes for Ordinary Field Peas in Weevil-infested Districts.

Owing to the ravages of the pea weevil in Southern Ontario, the importance of using substitute crops is becoming pretty generally recognized. Several varieties which might be classed under this heading have been grown in our experimental plots for several years in succession, the results of which are here presented :

Grass Peas. The Grass Pea is a leguminous plant, which produces long, flat vines, slender leaves, white blossoms, medium-sized pods, and hard, angular, white or greenish white, seeds (Fig. 6). It is entirely proof against the attacks of the pea weevil. In many respects it resembles the bitter vetch (*Lathyrus sativus*), of Europe, which, however, has blue flowers, and brown seeds. It also appears to be free from the poisonous principle which the bitter vetch is said to possess. This is borne out by scientific investigations which have been made, and by the extensive and satisfactory use of the Grass peas as a food for farm stock. They are highly prized as a regular farm crop in some sections of Southern Ontario where they have been extensively grown and fed for several years. They have been largely used as a substitute for the ordinary peas in some of those sections where the pea weevil has been doing serious damage for many years. In 1902, however, Grass peas, as well as nearly all other leguminous crops, were a partial failure, owing to the cold, wet weather of the summer. The yield of the Grass peas for 1901 was also below the average in some localities, owing to the excessively hot weather at the time of blossoming. For feeding purposes, they seem to compare favorably with the ordinary field peas. They are usually sown alone, but sometimes with oats and barley. The crop may be used as green fodder, or as hay, or may be ripened fo the production of grain, for which purpose, one and one-half bushels of seed per acre are usually sown with a grain drill. The straw is richer than that of any of the grain crops; and the peas are very hard, but, when ground, make a rich meal that is relished by cattle, sheep, and hogs. The meal of the Grass pea, being rich in flesh-forming constituents, should form not more than about one-third of the entire meal ration for farm stock. In this respect, it is very similar to the meal of ordinary field peas. Grass peas, however, cannot take the place of garden peas for table use, nor of field peas for the export trade.

Fig. 6. The *Grass Pea*, showing the thin, grass-like stems, the white flowers, and the pods containing white, angular peas. (Original.)

The Grass peas have been grown in the trial grounds at the college for at least nine years, and have given good results, except in 1902, when they were a partial failure owing to the cool weather and excessive rainfall. In the average results of tests made for a period of seven years it is found that the annual yield of grain has been 25.7 bushels, and the yield of straw 2.2 tons per acre. In 1900 the yield was slightly over 43 bushels per acre. The grain has been exceptionally heavy, the average weight per measured bushel being about 64 pounds. In comparing the results of the Grass peas with the Golden Vine peas (the common, small, white pea of Ontario), for a period of seven years, we find that the latter has given an average annual yield of 1.4 bushels of grain per acre more than the former; but that the former has given a yield of 4-5 of a ton of straw per acre, and grain which has weighed fully four pounds per measured bushel more than the latter.

In the average results of 27 co-operative experiments conducted throughout Ontario in 1901, the Grass pea gave about 3-4 of a bushel per acre less than the Early Britain variety, and 1-2 bushel per acre more than the White Wonder variety.

To compare the value of Grass peas and Common Tares, or vetches, for green fodder, seed of these varieties was distributed throughout Ontario for co-operative experiments in the years 1897, 1898, 1899, 1900, and 1901 The average results of these experiments for the five years were Grass peas 6.7 tons, and the Common Tares, or vetches, 6.8 tons per acre.

Egyptian Peas. The Egyptian pea is a leguminous plant, grown extensively in the Mediterranean regions, and in Central Asia. It has many common names, such as the Coffee pea, Chick pea, Idaho pea, Gipsy pea, etc., and is scientifically known under the name of *Cicer arietinum*. It has been used as feed for cattle, and also as an article of human food for upwards of 3,000 years. The seed is somewhat larger than that of the common pea, and is enclosed in a short, thick, hairy pod, there being from one to two peas in each pod. The plant itself is seldom used except as a soil renovator, but the yield of grain is large, and is ground into meal which makes a very valuable stock food when fed in much the same way as cotton seed meal. The straw is of little value. As a human food the peas are used in various ways. The ripened grain is sometimes prepared for the table in much the same way that we prepare our Canadian beans for culinary purposes. It is also sometimes roasted and used as a substitute for coffee.

The average results from growing Egyptian peas in our experimental department are a yield of one ton of straw and 35.6 bushels of grain per acre, the grain weighing a little over 62 pounds per measured bushel. It will, therefore, be seen that the Egyptian pea is a large yielder of grain. It is, however, slow in reaching maturity, and posesses straw which is short and of poor quality. The crop is usually slow in maturing, requiring about two weeks longer to ripen than ordinary field peas. As the plants are usually short in growth, the Egyptian peas are suitable only for very rich soil. As was the case with nearly all of the leguminous plants, the Egyptian peas were a partial failure in 1902, owing to the unusually cold, wet weather.

Egyptian peas were distributed for co-operative experiments throughout Ontario for four years in succession. In the average of 180 successfully conducted experiments, the annual yield was found to be only 21.1 bushels per acre. So the Egyptain pea does not seem to be suitable for the average soil of the Province.

Cow Peas. Nearly all the varieties of Cow peas (*Vigna Sinensis*) require such a long season of growth that they are suited only to the warm climate of the south. A few of the earlier kinds have been grown in the Northern States and have been tested at our experiment station at Guelph. We have as yet, however, been unable to find any variety of Cow peas on which we can depend to produce ripened grain, as our season is short, and it is only in exceptional years that even the earliest varieties of Cow peas will mature their seed.

Soy Beans. The Soy beans (*Glycine hispida*); also known under the names of Soja beans, Coffee beans, Idaho peas, etc., have been cultivated in China and Japan for a great length of time. The Soy bean is an annual legume; the plants have an upright growth and are almost completely covered with short hairs. The seed is generally sown at the rate of about one-half bushel per acre in drills from 2 to 3 feet apart, which are cultivated in a similar manner to our Canadian beans. The crop is used for green fodder, or is allowed to ripen for the production of grain, which is exceedingly rich, and when ground into meal is considered about as valuable as cotton seed meal for feeding purposes.

Eight varieties of Soy beans have been imported and grown in our Experimental Department. Some of the varieties have proved to be entirely unsuited for Ontario, owing to the long season required to reach maturity. The Early Yellow Soy bean, however, has given good satisfaction as a grain producer, and the Medium Green variety for the production of green fodder. The average result from growing the Early Yellow Soy beans for a period of seven years, has been 17 bushels of seed per acre. In the production of green fodder, the Early Yellow variety has produced an average of 8 and the Medium Green variety an average of 9.3 tons per acre for the same length of time.

The Early Yellow Soy beans were distributed over Ontario last year for co-operative experiments, and the average yield of grain as produced on thirteen Ontario farms was 21.4 bushels.

We believe it would be a decided advantage to Ontario farmers to grow the Early Yellow Soy beans more generally for the production of grain for feeding purposes; and the Medium Green Soy beans for placing in the silo with corn.

Vetches. Both the Common Vetches and the Hairy Vetches are serviceable when grown alone or with oats or barley for the production of green fodder, but are not suitable for the production of seed for feeding purposes.

Emmer. This is a species of wheat, known under the scientific name of *Triticum dicoccum.* Emmer is grown at the present day in Switzerland, Germany, Russia, Spain, and some of the other European countries. When the grain is threshed, the heads break at the different joints, leaving the grain in the chaff as closely clasped as ever. To secure the clean seed, special machinery is necessary to separate the chaff from the grain. The flour obtained is said to produce a coarse bread. It is doubtful if Emmer will ever be grown extensively for flour production in Ontario, but the indications are favorable for its becoming a regular and valuable crop for stock feeding. The grain, when ground with the chaff, appears to make a meal of good quality, and the straw is considered by many to make very valuable feed. Emmer is incorrectly called Spelt, or Speltz, by many seedsmen and farmers in Ontario and in the Northern States. The true Spelt (*Triticum spelta*) is quite distinct from Emmer, and is generally considered much inferior.

Different varieties of both Emmer and Spelt have been grown in the experimental grounds at Guelph within the past thirteen years, the former producing good, and the latter, poor results in nearly every case. In the average results from growing Emmer in the trial grounds for the last three years, the yield of grain has been upwards of 2,300 pounds per acre, which is about equal in weight to 68 bushels of oats, or 48 bushels of barley.

Emmer has been distributed throughout Ontario for two years and tested with other kinds of spring wheat. The Emmer surpassed the Wild Goose spring wheat in yield of grain per acre by 46 per cent. in the average of thirty-nine co-operative experiments in 1900, and by 63 per cent. in the average of thirty-one co-operative experiments in 1901. It will, therefore, be seen that Emmer is a large yielder of grain, and that it might be well to give it a trial, especially in those sections where the pea weevil is troublesome.

Other Substitute Crops. Besides the different varieties of crops here described, an increased area of our prominent cereals, such as oats, rye, six-rowed, two-rowed, and hulless barley, might be grown, either separately or in various combinations. These crops are too familiar, however, to require any detailed description.

Mixtures composed of oats and barley; oats, barley, and Wild Goose spring wheat; or oats, barley, Wild Goose spring wheat, and Grass peas, which are sown and allowed to ripen, usually yield more per acre than any one of them when grown by itself, or than peas and oats when grown in combination. Mixtures of oats and tares and of oats and Grass peas, are sometimes used instead of oats and field peas for the production of green fodder and of hay.

### Treatment for the Pea Weevil.

Within the past seven years about thirty different treatments of peas have been made in the Experimental Department for the destruction of the pea weevil. In handling the crop, care has been taken throughout to pull the peas at the proper time, to haul them to the barn when dry, and to thresh them as soon as possible. The late varieties have usually been threshed immediately on coming from the field, but the early varieties have sometimes remained in the barn for a few days, or perhaps for even a week. The threshing has usually been done with a machine, but occasionally with a flail.

Method of Fumigation. Immediately after threshing the peas were put into cotton or jute bags. As soon as thirty bushels of peas were threshed they were placed in a fumigation box for treatment. One pound of carbon bisulphide was poured out into three flat pans, which were placed on the top of the peas; the cover was then put on the box and weighted with heavy stones. After forty-eight hours the cover was removed and the box ventilated. The pans had become dry, as the liquid had changed into a gas, which, being much heavier than air, had sunk down amongst the peas penetrating them and killing the weevils. The quantity of carbon bisulphide used by us was larger than that usually recommended, as a pound or a pound and a half is generally considered sufficient for 100 bushels of peas, but we wished to err on the safe side.

Effectiveness of Fumigation. Only once during the seven years did we find live weevils after treatment. In this instance, the treatment was repeated by using one and one-half pounds of the liquid, but again a few live weevils made their appearance. After a third treatment, however, with two pounds of the liquid, no live weevils could be found. We were never able to account for the ineffectiveness of the treatments at this particular time. On all other occasions, the insects were destroyed by the first treatment, no matter whether they were in the larvae form, in the pupa stage, or had become fully developed. We find, from correspondence with a large number of exporters, that the treatment with carbon bisulphide is almost always effectual in killing the weevils with one treatment. One of our exporters, however, writes us as follows:

"Carbon bisulphide treatment has not always been successful in killing all the weevils in the peas. The amount of carbon bisulphide which I have found to give the best results is one gallon to two carloads of peas, or 450 to 500 bags. (This is a little more than one pound to 100 bushels). It is generally assumed that the treatment in the air-tight chamber, or "bug-house," for a period of 24 hours will be effectual. Last year, however, having a quantity of peas for shipment to the English market and being desirous of treating them effectually, I placed them in the "bug-house," and kept them there for nearly a week, and gave them two treatments of carbon bisulphide. After the peas reached England my correspondents there reported that there were still some live weevils in them

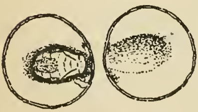
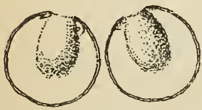
I can account for this only on the supposition that at the time of the treatment some of the weevils had not advanced in their development as far as the rest, and that there was less of the inner part of the pea consumed, and that, consequently, the thicker covering protected the weevil from the action of the carbon bisulphide."

The weevils usually die soon after the laying of the eggs on the young pods, but the exact duration of the life of an adult weevil, so far as we are aware, has never been definitely ascertained. It may be that the weevil lives some weeks after the deposition of the eggs.

A somewhat remarkable occurrence of live weevils in peas is told us by a reliable observer. A shipment of peas was fumigated in Ontario, shipped to England, and stored in a seed ware-house. For some reason or other, these peas were left undisturbed for nearly two years; and in the handling of the peas, a few live weevils were found. This case is, of course, abnormal, and simply means that some weevils may survive after two years of torpor, induced by cold; but it also shows that pea-dealers should be exceedingly careful in their shipments, lest some of the live weevils be carried to new districts.

ESCAPE OF THE WEEVILS. The time of escape of the weevils from the peas is, unfortunately, so variable and irregular, that it may be said with a great deal of truth that they keep on escaping in July, August and September, and from early April to the beginning of June.

It would be a comparatively simple matter to kill the great majority of the weevils with carbon bisulphide, as explained, if they always remained long enough in the peas to allow for the unavoidable delays in harvesting the crop, threshing the peas, and treating the seed. Some of the weevils may escape, however, before the peas are even harvested. The peas grown on the College Farm, in 1901, were threshed in the field with the College separator on the 15th day of August. The pea crop had not been stacked, but was threshed directly from the land and as soon as it was properly cured; and even at that early date, some of the weevils had escaped from the peas. The unevenness in the development of the weevils in the individual peas of the same crop is likely due to the unevenness in the blossoming of the peas in the different parts of the same field, in the individual plants growing side by side, and in the different parts of the same plants. Several repeated examinations have shown that peas grown on even a small plot in the experimental department and fumigated immediately after they were harvested contained weevils in almost every possible stage of development. To illustrate this fact, the Marrowfat variety has been selected. Two hundred average peas grown and treated in each of four years have been carefully examined. In order to represent the results obtained, four stages in the development of the weevils were selected as the basis of classification. The classification, therefore, is represented as follows: 1. Larva, one-eighth grown; 2. Larva, one-half grown; 3. Pupa; and 4. Adult Beetle, escaped. Every weevil in the peas was placed in the class which it resembled most closely. The following table gives the results of this examination of the development of the weevils at the time they were fumigated.

| Stages in the development of the pea weevils at the time of fumigation. | | Average percentage of weevils at each stage of development when fumigation took place. 1897 | 1898 | 1900 | 1901 | Average 4 years. |
|---|---|---|---|---|---|---|
|  | Larva ($\frac{1}{3}$ grown) | 1 | 14 | 7 | 20 | 11 |
|  | Larva ($\frac{1}{2}$ grown) | 2 | 27 | 10 | 25 | 16 |
|  | Pupa | 47 | 59 | 82 | 53 | 60 |
|  | Adult escaped | 50 | .. | 1 | 2 | 13 |

These results are very suggestive. They throw much light upon the probable effectiveness of the fumigation process in the eradication of the pea weevil. It is owing to the irregularity in the development of the weevil that some of the insects escape so early in the season, while others remain in the peas until a much later date.

In some seasons, the weevils develop and escape much earlier than in others. It is quite probable that the conditions of the weather, such as temperature and moisture, exert an influence on their development. In 1902, the weevils did not escape until much later in the season than usual, evidently owing to the wet, cold summer.

Moreover, it is a matter of common observation throughout the country, that many pods shell their peas in the field while the crop is being harvested. If the peas were pulled just before they ripened, not only would there be less shelled peas on the ground, but the straw would be of much better quality. Hogs turned on the pea stubble would eat a few of the scattered peas and the weevils which they contained. If the peas were stirred into the soil by a cultivator, or turned under with a plow, it is quite probable that some of the weevils would be destroyed by this process.

Weevilly peas which remain in the straw after the crop is threshed, which lodge in the separator to be scattered on the ground, which lie on the threshing floor for several days after threshing, etc., give the weevils an opportunity to escape.

In any effort to destroy the pea weevil, attention must be given to garden peas. Most persons do not realize that when a mess of green peas is eaten, a large number of the grubs of the pea weevil are (to put it mildly) prevented from doing further damage. If all the garden peas were eaten in this way and prevented from ripening, there would be no danger to the general pea crop from such a source. An effort should be made, therefore, neither to allow any garden peas to ripen nor any seeds containing live weevils to be planted.

Carbon Bisulphide. Carbon bisulphide is a colorless or slightly yellowish liquid, one-fourth heavier than water. It is extremely *volatile*, i. e., evaporates very rapidly when exposed to the air, and when pure will not injure or stain the finest goods. The commercial liquid has an acrid taste, and an odor like that of rotten eggs. The vapor is more than two and a half times as heavy as air. Carbon bisulphide may be purchased in small quantities from any druggist at about 30 cents per pound, or 40 cents per pint. For larger quantities, better rates can be given by the druggist. The gas, or vapor, which comes from carbon bisulphide is not only combustible, but it is very explosive when mixed with air. Great care should, therefore, be taken to treat the peas in the daytime only, for a light or a flame of any kind brought near the liquid may cause a serious explosion; and smoking near it should be positively prohibited. Moreover, the vapor should not be inhaled, as it is very injurious, even a small portion causing headache, giddiness, and nausea. The treatment with carbon bisulphide should be made in boxes, barrels, or "bug houses," located some distance from the insured buildings on the farm.

With the strict observation of the preceding precautions, no one should hesitate to use the carbon bisulphide. As a matter of fact, we have never heard of any bad results following its use in the treatment of peas. This happy condition of things may be explained when we say that all who used the liquid were wise enough to be cautious. There is, moreover, no danger that the vapor will injure the peas or render them unsafe as food. Experiments have shown that the liquid can even be poured upon articles of food, and, after thorough exposure to the air, not a trace of it will remain.

FUMIGATION BOX. The fumigation box which has been in use in the Experimental Department for seven years for killing the pea weevil by the carbon bisulphide process is well illustrated by the accompanying diagrams ( Fig. 7 ). The box is rectangular in form,

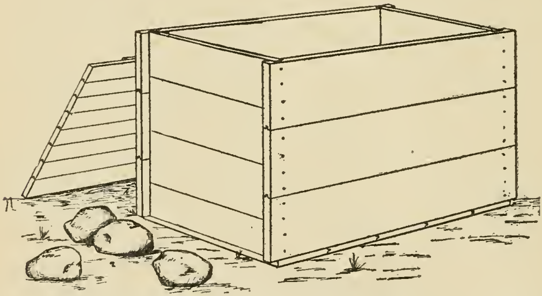


Fig. 7. Fumigation box used in the Experimental Department at the O.A.C. The method of construction is readily seen. (Original.)

being five feet long, two and four-fifths feet wide, and three feet high, and capable of holding about thirty bushels of peas at one time. It is made of pine lumber, $1\frac{1}{2}$ inches thick, tongued and grooved. The end pieces are mortised into the sides. All the joints are made very tight by the use of white lead. The cover is lined with a strip of cloth and is made to fit very closely. This box has been used for the double purpose of fumigating peas to kill the weevils, and of dipping sheep to kill the ticks.

COAL-OIL BARRELS. When a box such as we have described, is not readily made or procurable, one or more *coal-oil barrels* may be used. These are water-tight, and may be covered with a blanket and a close fitting cover, upon which may be placed some heavy stones. Fig. 8 shows the method of using barrels for this purpose. A barrel will hold about five bushels ; and for this quantity of peas, three to four ounces of carbon bisulphide are necessary.

This method of treatment is valuable for small quantities of seed peas, but would hardly be adopted when the entire season's crop is to be fumigated, as it would necessitate either a very large number of barrels, or an extended period of fumigation with a few barrels.

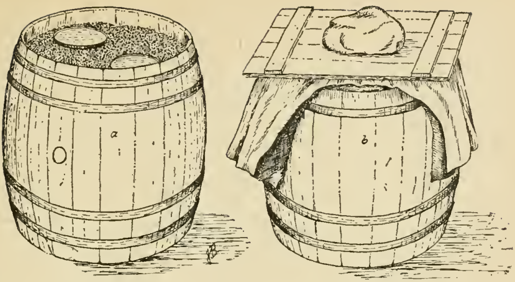



Fig. 8. Method of treating peas in coal-oil barrels. (*a*) Shows the carbon bisulphide in two pans on the surface of the peas ; (*b*) shows how the peas are fumigated. (Original.)

Bug Houses. Many of our large buyers and shippers of peas have specially constructed air-tight chambers, or "bug houses," in which several hundreds of bags of peas are treated at one time with carbon bisulphide. In some cases, farmers, especially when the pea crop is large, could profitably erect "bug-houses." It is not necessary in all instances to construct a separate building for this purpose. It would be more economical for the farmer to build a compartment in his barn, as it would make tight, clean storage for grain, robes, blankets, or other articles, during the portion of the year when it is not used for treating peas. This may affect insurance.

A chamber 12 feet long, 6 feet wide, and 8 feet high is about the right size for treating the season's crop. Besides the siding on the outside of the frame, there should be two thicknesses of dry tongued-and-grooved matched lumber, with building paper between, well nailed on the outside of the fame. The ceiling should also be made in a similar manner. The beams and joists of the building should be so rigid that they will not give in the least when loaded, lest a crack be made in the side, and allow the gas to escape. The floor should be made of two thicknesses of sound, matched, tongued-and-grooved lumber, with building paper between the thicknesses.

The door-way should have two doors, an inner one not on hinges, but have two handles with which to lift it and put it in place, and an outer one which is hinged. Both of these doors should fit against rubber or felt strips laid on grooves cut in the door-frame. The doors can be wedged tight against the rubber padding by means of three oaken cross bars (at the bottom, middle, and top) which can be driven like wedges into slots cut in the door-casing. (See Fig. 9.)

*Other Methods of Treating Peas.* The method of *holding over peas* in closed bags or tight boxes for a year is one which has been in operation for many years. The weevils which escape from the seed soon die, and are not able to lay their eggs in the field. This method is only partially effective, since many weevils make their escape before they can be bagged.

The *boiling water* treatment has also been used for many years. The infested seed is thrown into boiling water for one minute, then quickly removed. This method has never been widely adopted, since the germ is very apt to be injured by longer immersion than one minute in the boiling water.

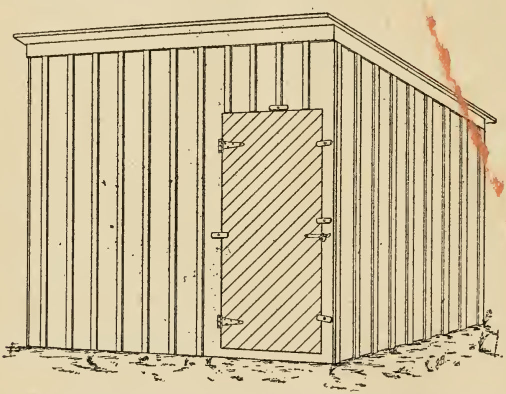


Fig. 9. Fumigation house at the Ontario Agricultural College. There are two doors, one in front and the other in the rear, to facilitate ventilation ; the door is driven up tightly against the felted casement by means of large wooden buttons. (Original.)

Infested peas may be treated successfully by *heating* them to a temperature of 145° F. without injury to the germ, but this method has never been widely adopted, for obvious reasons.

Although we have never tried the *coal oil treatment*, some of our correspondents report successful results, and outline the process as here described : The peas are spread on the barn floor in a thin layer about six inches deep; and the oil is sprinkled over the seed through a machine oil-can. Then the peas are turned over very thoroughly so that every pea becomes coated with a thin film of oil. In this condition the peas are left for two or three days, when it will be found that the weevils have been killed. One quart of oil is sufficient for twenty bushels of peas.

This method is to be recommended in the treatment of small quantities, such as seed peas ; but we are of the opinion that it would not be a practicable method for treating peas in large quantities immediately after harvest.

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 127.

# FARM POULTRY

WITH THE RESULTS OF SOME EXPERIMENTS IN

# FATTENING CHICKENS,

BY

W. R. GRAHAM, B.S.A.,
POULTRY MANAGER AND LECTURER.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
TORONTO, ONTARIO, MAY, 1903.

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# THE ONTARIO AGRICULTURAL COLLEGE

AND

# EXPERIMENTAL FARM

## GUELPH, ONT.

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**HON. JOHN DRYDEN, Minister of Agriculture, Toronto, Ont.**

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BULLETIN 127. MAY, 1903.

Ontario Agricultural College and Experimental Farm.

# FARM POULTRY, WITH THE RESULTS OF SOME EXPERIMENTS IN FATTENING CHICKENS.

By W. R. Graham, B.S.A., Poultry Manager and Lecturer.

This Bulletin is intended to give information to farmers and others, on general matters pertaining to the keeping of poultry.

It also contains the results of a few experiments which have been conducted at this institution in fattening chickens for the home and export market.

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## CONSTRUCTION OF POULTRY HOUSES.

We find poultry thriving and yielding good returns in so many different styles of houses, that it is very difficult to lay down any hard and fast rules. The tendency at present is towards cheaper houses, with better ventilation. The hot-house style of housing poultry during the winter has not been satisfactory, many of the houses being damp, and the air in them anything but agreeable. Disease has been quite common; and the results in many cases have been disappointing. To the plans given below, there are no doubt some objections; but there are strong points in each. Many of these houses are giving excellent results in Ontario.

Every poultry house should be light; at least one-third of the south side of it should be of glass, or otherwise opened to the sun. It should face the south-east or south. The sun's rays are very beneficial to fowl, especially during the winter months.

### Poultry House of L. H. Baldwin, Deer Park (Toronto).

Mr. L. H. Baldwin's poultry house is a good one. It is well planned and has given good results. I have always found Mr. Baldwin's fowls very healthy and in good laying condition. The point of excellence in this plan of a house is that the fowls are allowed exercise in the open air, and are, at the same time, protected from the wind. It also furnishes a warm roosting pen.

After a very full inspection of several hen-houses erected on many of the leading poultry farms of the Eastern States, Mr. Baldwin decided to build a hen-house on the scratching-shed plan. He came to the conclusion that this plan was best suited for a climate such as they have in Toronto.

His hen-house is a frame building 72 feet long and 10 feet deep, and is divided into four scratching-sheds and four hen-houses proper. The ground plan is shown in Fig. 1. The sills are 4x4 cedars, resting on large stones. The end sill rests on stone, and the sill running the length of the building rests on top of the end sill. The studding used is 2x4 hemlock. The top of the sill is one foot above the surface of the ground, and a base-board is fastened on the inside of the sill, and the floor of the hen-house is filled with sand to the top of the base-board. The building is banked up on the outside to the same level. The stones upon which the sills rest are placed at varying distances to meet the joists and at intervals of about 8 feet. The north wall is 4 feet high from the top of the sill, and the south wall 7 feet high. In the north wall, the studding is placed at each corner of the hen-house proper and an additional one in each centre, also at the corner of each scratching-shed, and an additional one in the centre. In the south wall the studding is placed in the same way, excepting the one in the centre of the hen-house, which is placed so as to accommodate the window. At the east end, an extra stud stands as a door post; and one at the west end, in the centre. For rafters, he used 2x4 hemlock, placed at 2 feet centres. On the outside of the studding and rafters he used the most ordinary lumber, running the boards lengthwise. The ends of the building, the north wall, and the south fronts of the hen-house proper are covered with a two-ply "ready roofing;" and for the roof he used three-ply "ready roofing." A scantling 2x4 reaches from the north sill to the south sill at the base of each division between scratching pens and hen-houses proper, and between the hen-houses. The division wall between the scratching-shed and the hen-house is made of rough lumber on the scratching-shed side with a lining of tar felt nailed on the interior of these boards, and battened closely with laths to make the joints of the tar felt complete. The division wall between the hen-houses proper is made of 7x8 tongued and grooved flooring, and the other interior walls of the hen-houses proper, that is, the walls against the scratching-sheds and the north and south walls, are lined with 7x8 tongued and grooved dressed material. The ceiling is also completed in the same way. But before the putting on of this dressed material, a second layer of tar felt was placed between the sheeting and rafters, so that there is a dead-air space. The large doors between the scratching-sheds and the hen-houses proper are about three inches thick, made of two thicknesses of 7x8 tongued and grooved dressed material, with a space of one inch between, and lined with tar felt on the inside of each thickness. These doors are raised a foot above the level of the sills, and in this space near the south wall is cut small doors for the poultry, 10 inches wide, having sliding doors.

*Interior Arrangements.*

The dropping board is three feet wide and 18 inches above the level of the top of the sills. Two roosts, each 2x3, are placed on the

Fig. 1.

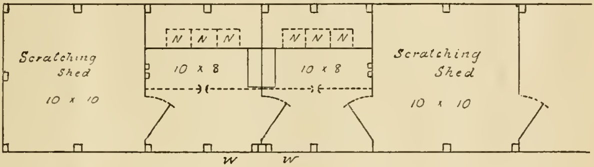
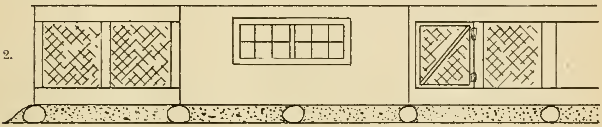
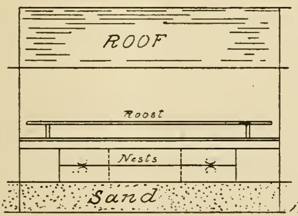



Fig. 2.





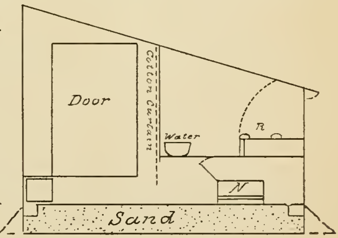




Fig. 3. Fig. 4.

POULTRY HOUSE OF L. H. BALDWIN, DEER PARK.

Fig. 1. Ground plan of one half of the house. Fig. 2. Front elevation. Fig. 3. Cross section of a single pen from east to west. Fig. 4. Cross section of a single pen from north to south.

flat side, fastened together by a cross strip which is hinged to the north wall. Two legs support the roosts on the outer side. The roosts being hinged, they can be lifted up and fastened to the roof so as to leave a clear space when making the daily cleaning. The roosts come short of each pen by about two inches. Three nests are allowed to each pen. These are each 18 inches square, having the ends solid. The nests are placed under the dropping board facing the north wall, rest on the sand, and can be taken out for cleaning. The back of the nest is made in two pieces. The upper part is fastened to the lower board by spring hinges, which enables one in collecting eggs to reach the nest conveniently ; and the spring hinges make the top board fly back into place. Against the inside division between the hen-houses proper, a 12 inch board extends on the level of the dropping board to within 12 inches of the door, and an upright 12 inch board is fastened to the end of this and runs up to the ceiling. To correspond with it, a board is placed against the opposite wall, and a cotton curtain on a two inch roller is fastened to the ceilling. This curtain is shown by the dotted lines across pens in Fig. 4 and at x in Fig. 1 When this curtain is down it comes to the bottom of the two last mentioned upright boards that is to about 2 inches below the level of the dropping board. The purpose of this curtain is to protect the fowls on very cold nights. Mr. Baldwin has found that it is not necessary to use it when the pens contain over 15 birds ; but if the number is reduced, and the thermometer drops to the neighborhood of zero, it is well to let it down.

### *Plenty of Light.*

The windows in front of the hen-houses proper are each three feet wide and two feet 6 inches high, containing 6 panes, 10x12 inches each. The windows are placed high in the front wall and slide to the right and left. The windows being placed high up, the sun in winter, when it is low in the heavens, shines on to the roost and dropping board. The door between the hen-houses proper, which is also a foot above the level of the sills, is a simple door of 7x8 inch stuff, the upper half being made of wire netting. The front of each scratching shed is divided in two by the centre studding, on each side of which there are cotton screens hinged at the top, and reaching down to within one foot of the top of the sill ; and, when down, close upon top of a rainboard which slopes to the outside, so that rain beating against the cotton screen is carried outside ; and this keeps the interior dry. These screens swing up to the roof, and are there caught by hooks from the rafters. The front of each scratching-shed is closed with two-inch mesh wire netting. (One-inch mesh should have been used to keep out the sparrows, which now get in and run off with a lot of grain). An eaves-trough runs the length of the building, distributing the water east and west. Drinking fountains are placed on the end of the board that runs out from the dropping board ; and on the wall opposite thereto the boxes for grit and oyster shells are hung.

### *Sanitary Precautions.*

The interior of the hen-houses and the scratching-sheds is filled with sand to the level of the top of the sill ; and on top of this a plentiful supply of loose straw is kept, to encourage the birds to scratch and thereby get exercise. In August the straw is all cleaned out ; and the sand, so far as it appears to be soiled, say, to a depth of four or five inches, is all taken out, and fresh sand put in its place. It is advisable to do this in August, so that the sand may become perfectly dry before the winter sets in. No straw is placed on top of the sand until the time comes to close the birds up for the winter. The windows of the hen-house proper are open every day. Of course, when the weather is stormy or bitterly cold they are open only for 15 minutes or half an hour in the middle of the day. When the sun is shining brightly they may be left open for some hours. This thoroughly ventilates the hen-houses, dries up all moisture, and keeps the place clean and sweet. The screen in front of the scratching-shed is let down only on very cold days, and when the weather is cold and stormy, the idea being to keep the open shed dry where the birds take exercise in the open air.

This method of housing poultry keeps the stock in the most vigorous health ; and this is the secret of Mr. Baldwin's success in obtaining a plentiful supply of fertile eggs. He began incubating in January last, and out of 1,100 White Wyandotte eggs set during the season he obtained 66 per cent. of chicks. The runs of his hen-houses extend to the north and west of his buildings, as it best suits the shape of his lot. The runs are in most cases placed to the south of the building ; and sometimes, where it is possible, they are extended north and south, and are used alternately. From the practical experience of five years' use of the building, Mr. Baldwin's opinion is that it is well adapted in this section of the country for keeping breeding stock and maintaining it in most vigorous health, which is the foundation of success. He keeps only White Wyandottes, and thinks that the building would, perhaps, be too cold for the more delicate breeds, although he at one time kept White Leghorns in it with considerable success. In one phenomenal hatch of Leghorn eggs he secured 95 chicks from 95 fertile eggs, out of a total setting of 100 eggs. This affords some idea of the vigor of the stock, and the fertility of the eggs secured from birds kept in hen-houses erected on this plan. Mr. Baldwin believes that many who have adopted the scratching-shed hen house have adjusted windows to the front of the scratching-shed in place of the screen ; and this might be an advantage, especially in sections of the country where the weather is more severe than in Toronto.

*Cost of the Building.*

He estimates the cost of his building at $250, allowing for his own time ; but on account of the increased cost of lumber and labor, a similar building would now cost about $300. The cost, of course, depends upon the facilities for obtaining material and labor. He keeps about 18 hens in each pen during the winter, and obtains a plentiful supply of eggs.

## The Poultry Houses at O. A. C.

The Colony House in use at this College is more or less of an experiment, but it is cheaply constructed, and allows a warm roosting pen and exercise in the open air. The canvas door protects the fowls

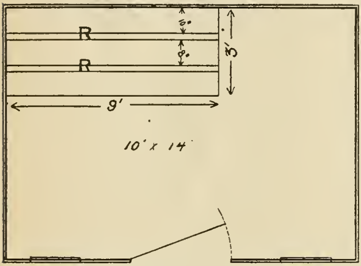



Fig. 5.—Ground plan of colony house at O.A.C.

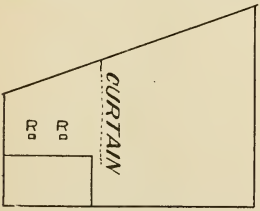



Fig. 6.—Cross section of colony house.
R, R, roosts.

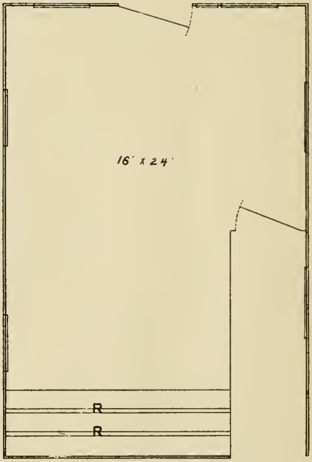



Fig. 7.—Ground plan of closed pen.
R, R, roosts.

from the extremely cold winds. In very severe weather the board door in front of the house may be shut.

This house is made of a single thickness of planed lumber, the cracks between boards being covered by battens. It is not sheeted on the inside, except in the roosting compartment, which is lined with paper and matched lumber. We wintered Plymouth and Wyandotte fowls successfully in this coop before the roosting compartment was put in. It was, however, so cold at night time, in very severe weather, that egg production was practically stopped for a day or two. I would not recommend its use where Leghorns or such birds are to be kept. This house will accommodate from 20 to 25 chickens.

The plan of the closed house in use at this College (see Figs. 7 and 8) is designed to admit of exercising the fowls in the open air, to have a constant supply of fresh air, and a warm roosting pen. Formerly, this house was equipped with double doors, walls, and windows; it was as tight as a drum, and there was a constant dampness during the winter, owing largely to a lack of fresh air.

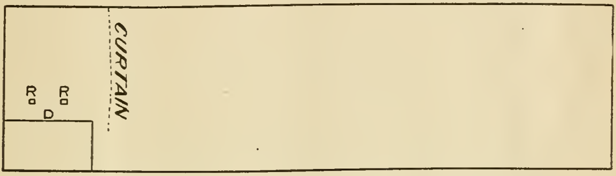



Fig. 8.—Crossed section of closed pen. R, R, roosts; D, dropping board.

The substitution of a curtain for the door on the south side will, we are satisfied, admit abundance of air and do away with the dampness. This house will accommodate from 40 to 50 fowls.

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## GENERAL RULES FOR BUILDING.

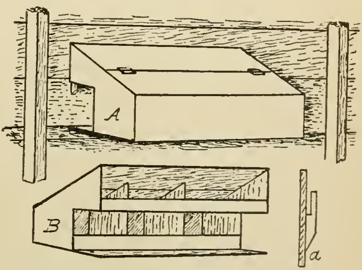
Every hen should be allowed at least 6 square feet of space in the scratching pen, and about 4 square feet in the roosting pen. Each bird of the Plymouth Rock, Wyandotte, and such breeds, requires about 9 inches of perch room; Leghorns, etc., about 8 inches; and Brahmas, 10 inches.

Roosts should be made low, or near the ground. There are several reasons for this. Fowls of the heavier breeds cannot fly high, and those of the lighter breeds frequently injure the soles of their feet in jumping from high perches.

When dropping boards are used, they should be moderately low down, to admit of easy cleaning. Dropping boards should be made of matched lumber, and should be 20 inches wide for one roost, and three feet for two perches, the first being placed eight to ten inches from the wall.

Most poultry men prefer roosts 2 inches by 2 inches, with edges slightly rounded.

*Nests.* Many use only old boxes; but such nests, if near the ground, are apt to induce egg-eating. Dark nests prevent this. (Figs. 9 and 10.)




Figs. 9 and 10. Front and back views of nests. (*Poultry Craft.*)

Nests are usually made from 12 to 15 inches square.

Ground floors are more in favor than board floors, and cost much less.

In my own experience, the best results are obtained from keeping 20 to 25 birds in a flock. Some succeed with 60 to 75 in a flock; but these are the minority.

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## BREEDS OF POULTRY.

*Plymouth Rocks.* There are three varieties of this breed, viz., Barred Plymouth Rocks, White Plymouth Rocks and Buff Plymouth Rocks. The Barred variety is the oldest and most popular, owing to its having been introduced some years previous to the last two named varieties.

The same general characteristics apply to the three varieties. They are fairly hardy, good winter layers, fair summer layers, lay brown eggs, make fair mothers, are sitters, have naturally yellow legs and flesh, have single combs, and are all-round good general purpose fowl.

The standard weights are: Cock, 9½ lbs.; cockerel, 8 lbs.; hen, 7½ lbs., and pullet, 6½ lbs.

*Wyandottes.* There are several varieties of this breed, viz., White, Black, Buff, Silver-Laced, Golden-Laced, Partridge, and Silver-Pencilled.

The last two varieties are comparatively new, and are not at present nearly so plentiful as are the other varieties.

The White Wyandotte is bred by many market poultrymen, and is very popular.

This breed, in its different varieties, possesses the same general characteristics as the Rocks, with the exception that they have a rose-comb and are more blocky in appearance.

The standard weights are: Cock, 8½ lbs.; cockerel, 7½ lbs.; hen, 6½ lbs., and pullet, 5½ lbs.

*Rhode Island Reds.* This breed is bred extensively by the farmers in the State of Rhode Island, where it originated. It has not as yet been admitted to the American standard of perfection. Hence we have no official description of the breed, except that given by the Rhode-Island-Red Club.

They are said to be fairly hardy, fair winter and summer layers, are setters, only fair mothers, brown egg breed, have yellow legs and skin and mature early. They are a reddish buff in color, with a strong tendency to black colored tails and wings; also black ticking in the hackle feathers.

The R.I.R. Club gives the following weights: Cock, 7 lbs.; cockerel, 6 lbs.; hen, 5½ lbs., and pullet, 4½ lbs.

*Orpingtons.* There are three varieties of this breed, viz., Black, White, and Buff Orpingtons. The Buff variety is far more popular than the other two. Buff Orpingtons seem to be well adapted to this country, and have the color of flesh sought after in the British market. They will certainly be great rivals of the Rocks and Wyandottes as the farmers' fowl.

They are fairly hardy, good winter layers, brown egg breed, are setters, good mothers, have white legs, white skin, and usually have single combs. There are a few rose-comb Buffs, but they are rather scarce.

Standard weights: Cock, 10½ lbs; hen, 8½ lbs.; cockerel, 9 lbs., and pullet, 7 lbs.

In breeding this variety, where market chickens are wanted, I would prefer birds of at least one pound less in weight than the standard weight given.

*Leghorns.* There are several varieties of Leghorns. The most popular are the Single-Comb White, Brown, Buff, and Black. The Rose-Comb White and Brown are also bred to some extent.

All Leghorns are considered to be non-sitters. An occasional one shows some inclination to sit, but these are not to be relied upon. They are excellent layers, especially during the summer months. The eggs are white in color. As a rule, the Single-Comb White lays a larger egg than the other varieties.

Leghorns require a fairly warm house on account of the size of their comb, particularly the male bird. These birds are fairly hardy and vigorous. They are too small for table use, unless as broilers.

*Minorcas.* The Single-Comb Black is the most popular variety. The Rose-Comb Black and Single-Comb White are not so generally bred. This breed is larger than the Leghorn or Andalusian. They lay very large white eggs. They are a good summer layers and are usually non-sitters. Their very large combs are an objection in cold climates. These fowls are fairly hardy and vigorous.

Standard weight: Cock, 8 lbs.; hen, 6½ lbs.; cockerel, 6½ lbs.; pullet, 5½ lbs.

*Blue Andalusians.* This breed is midway in size between the Minorca and Leghorn, and generally non-sitters, and lay a large white egg. They are splendid summer layers. The chief objection to them is that they do not breed true to color, the chicks coming blue, black, and nearly white. There are usually about 50 per cent. blue chicks. The size of their combs is also considered an objection in a cold climate. They are fairly hardy and vigorous.

Standard weight: Cock, 6½ lbs.; hen, 5½ lbs.; cockerel, 5½ lbs.; pullet, 4½ lbs.

*Games.* The Indian Game is the chief variety of interest to the farmer. They are a good market fowl, having a splendid development of breast meat; but their breast is considered by some to be rather short. They are fairly hardy, but are only moderate layers of medium-sized brown eggs. They are good sitters and mothers. Crossed with Dorkings, Rocks, or Wyandottes, they make excellent fowls for the market. These crosses are, however, seldom good layers.

Standard weight: Cock, 9 lbs ; hen, 6½ lbs.; cockerel, 7½ lbs.; pullet, 5½ lbs.

*Dorkings.* There are several varieties of this breed, the most popular being the Silver Grey and colored varieties. Birds of this breed are among the best market fowls yet produced, and they are fair layers of good-sized, white eggs. They are fair sitters and mothers. They have white legs, white skin, and five toes.

The fault of this breed in Ontario is that they do not do well in confinement, and are not considered hardy. With some farmers, however, they are very popular.

Standard weight of Silver Grey variety: Cock, 8 lbs.; hen, 6½ lbs.; cockerel, 7 lbs.; pullet, 5½ lbs.

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## EGG PRODUCTION.

To produce eggs in winter time, we have to consider the stock, the quarters or housing, the feed, and the weather.

*Stock.* The stock needs to be the best obtainable. An ideal bird for winter egg production is a pullet that is mature at about Nov. 1st, and is strong and vigorous, and of a good laying strain. Something depends upon the breed, but more on the strain of the breed; also much upon a good strong constitution, and an abundance of vigor. These are the essential points.

To get pullets of such birds as Rocks, Wyandottes and Orpingtons matured by November, it is necessary to hatch them in April. Some seasons May chicks mature quickly and begin laying about the first of December, but not as a rule. If a pullet does not commence to lay before Christmas, it is doubtful if she will begin much before March, unless the weather is favorable. Then again, good yearling hens that have moulted early are likely layers. The problem, how to get hens to moult early, is not entirely solved as yet. No doubt it has been noticed that hens which sit and bring out a brood of chicks from June 10th to July, usually moult about the time they are leaving their chicks. Some hens that sit earlier also moult early; but as a rule they begin to lay after sitting, and are rather inclined to late moulting,

From the above, it would appear that the best method to get the flock in general to moult would be to place the flock under conditions similar to those of the sitting hen. This is done by some egg-farmers with more or less success. The plan followed is to change the hens to a new, free range about July 1st, and feed but very lightly, not more than one handful of grain to each hen daily. The object is to induce the hens to dine largely on grass and water, and *stop egg production.* After being thus treated for from two to three weeks, the hens are again well fed on a good laying ration. In many cases they begin to moult; and, if fed well, get their new coat of feathers in quickly, and thereby save time. I have had a few hens which have begun to lay heavily as soon as I have started to feed them well; but this is not very often the case.

Hens over two years of age are seldom good layers. Leghorns Minorcas, etc., are sometimes good during their third and fourth years; but, generally speaking, the Rocks and such fowls are of little or no use as layers after the second year, being much inclined to become excessively fat.

For *summer egg production* the lighter breeds and late-hatched pullets of the heavier breeds are best. Do not expect a hen that has laid well all winter to lay exceptionally well during the summer. A hen that lays early is inclined to show a desire to sit early in the season. The following tables show plainly that eggs can be produced at a profit during the summer, even where all the grain has to be bought.

Egg-Production at the O. A. C. in 1901.

April 22 to May 22nd. Rocks—13 hens, 1 cock:

| | | |
|---|---|---|
| Mixed feed—17 687 lbs., at $1.33 per cwt | 23 526 | cents. |
| Bone—16.687 lbs., at $1 00 per cwt | 16 687 | " |
| Mash—32.375 lbs., at 90c. per cwt | 29 137 | " |
| Wheat—21.875 lbs., at $1.13 per cwt | 24.71 | " |
| Milk—32 lbs., at 10c. per cwt | 3.20 | " |
| Total | 97.26 | " |

Eggs laid, 16 dozen; cost per dozen, 6.08 cents.
Nearly all Rocks were broody during last week.

April 22nd to May 22nd. Andalusians—13 hens, 1 cock:

| | | |
|---|---|---|
| Mixed cracked grain—14.3 lbs, at $1.33 per cwt | 19 01 | cents. |
| Green bone—13.75 lbs., at $1.00 per cwt | 13.75 | " |
| Mash—35 lbs., at 90c. per cwt | 31.50 | " |
| Wheat—24 lbs., at $1.33 per cwt., or 68c. per bushel | 31.92 | " |
| Milk—35 lbs., at 10c. per cwt | 3.5 | " |
| Total | 99.68 | " |

Eggs laid, 20½ dozen; cost per dozen, 4.86 cents.

May 22nd to June 22nd—Barred Rocks:

| | | |
|---|---|---|
| Oats—2 lbs. 8 ozs., at $1.00 per cwt | 2.5 | cents. |
| Bone—2 lbs., at $1.00 per cwt | 2. | " |
| Mash—40 lbs., at 90c. per cwt | 36. | " |
| Milk—40 lbs., at 10c. per cwt | 4. | " |
| Wheat—34.8 lbs., at $1.13 per cwt | 39.32 | " |
| Total | 83.82 | " |

Eggs laid, 13 dozen and 10 eggs; cost per dozen, 6.15 cents.

May 22nd to June 22nd. Andalusians:

| | | |
|---|---|---|
| Milk—40 lbs., at 10c. per cwt | 4. | cents. |
| Oats—3 lbs., at $1.00 per cwt | 3. | " |
| Wheat—35.437 lbs. at $1.13 per cwt | 40.04 | " |
| Mash—40 lbs., at 90c. per cwt | 36. | " |
| Bone—11.375 lbs., at $1.00 per cwt | 11.37 | " |
| Total | 94 41 | " |

Eggs laid, 18 dozen and 2; cost per dozen, 5.06 cents.

June 22nd to July 22nd. Barred Rocks:

| | | |
|---|---|---|
| Wheat—26.375 lbs., at $1.13 per cwt | 29.80 | cents. |
| Oats—6.25 lbs., at $1.00 per cwt. | 6.25 | " |
| Mash—41.75 lbs., at 90c. per cwt | 37.57 | " |
| Milk—41 lbs., at 10c. per cwt | 4.1 | " |
| Bone—1 lb., at $1.00 per cwt | 1.00 | " |
| Total | 78.72 | " |

Eggs laid, 13 dozen and 10; cost per dozen, 5.69 cents.

June 22nd to July 22nd. Andalusians:

| | | |
|---|---|---|
| Wheat—35.625 lbs., at $1.13 per cwt | 40.25 | cents. |
| Oats—6.25 lbs., at $1.00 per cwt | 6.25 | " |
| Mash—40 lbs., at 90c. per cwt | 36.00 | " |
| Milk—40 lbs., at 10c per cwt | 4.00 | " |
| Bone—1 lb., at $1.00 per cwt | 1.00 | " |
| Total cost | 87.50 | " |

Eggs laid, 16 dozen and 1; cost per dozen, 5.44 cents.

July 22nd to August 22nd. Barred Rocks:

| | | |
|---|---|---|
| Wheat—32.625 lbs., at $1.13 per cwt | 36.86 | cents. |
| Oats—9 lbs., at $1.00 per cwt | 9.00 | " |
| Mash—35.9 lbs., at 90c. per cwt | 32.31 | " |
| Milk—40 lbs, at 10c. per cwt | 4.00 | " |
| Bone—2 lbs., at $1.00 per cwt | 2.00 | " |
| Total cost | 84.17 | " |

Eggs laid, 14 dozen and 1; cost per dozen, 6.2 cents.

July 22nd to August 22nd. Andalusians:

| | | |
|---|---|---|
| Wheat—27.25 lbs., at $1.13 per cwt | 30.79 | cents. |
| Oats—14.875 lbs., at $1.00 per cwt | 14.875 | " |
| Mash—40.5 lbs., at 90c. per cwt | 36.45 | " |
| Milk—40 lbs., at 10c. per cwt | 4.00 | " |
| Bone—3 lbs., at $1.00 per cwt | 3.00 | " |
| Total cost | 89.115 | " |

Eggs laid, 14 dozen and 9; cost per dozen, 6 cents.
Average cost per dozen for Rocks, 6.02 cents per dozen.
Average cost per dozen for Andalusians, 5.34 cents per dozen.

Housing. The housing of fowl was discussed in a previous paragraph. It is well to remember, however, that the house should be clean, the droppings being removed at least twice a week; it should also be well aired and kept dry, to avoid dampness and foul, stagnant air.

Feeds and Feeding. The main points to be considered in feeding are, that there be a good supply of green food, meat food, and grain, the latter both ground and whole. It is also necessary to feed so as to induce birds to take exercise. In winter green food is supplied by feeding cabbage, turnips, or other roots, pulped or whole, and by feeding steamed cut clover or clover leaves in the mash. Meat food is supplied in the form of ground green bone, cooked offal, such a beef heads, etc., and in the form of animal meal. In Ontario the ground bone is perhaps the best and cheapest, where one has a bone mill; where not, beef heads, livers, etc., give good results. Animal meal, dried blood, etc., are good foods, but in many cases are more expensive than the others mentioned. However, they are very useful during the hot weather, when it is almost impossible to use fresh meat. Partially decayed meat *should not be used*, as it is not healthful.

Wheat is undoubtedly the most popular grain food for fowl in Ontario. It is certainly a good food, and is very much relished by poultry.

Corn is not used so much in Ontario as in New England States. There it appears to be used quite freely in both summer and winter feeding of fowls. It is used whole, ground, and cracked, the meal being used principally in the mash foods. Cracked corn is used largely for young chicks and fowls when scattered in the litter. The whole corn is rather large and conspicuous; and, when in the litter, does not give enough exercise. I am of the opinion that corn can be used in portions of Ontario, where it is grown extensively, much more freely than it has been heretofore. Corn is a heating and fattening food, and is therefore best adapted for winter use. It is considered by many, when fed in large quantity, to make the hens fat; yet it is used extensively by many progressive poultrymen with little or no evil effects.

Oats should be a first-class food for poultry; but, owing to the large percentage of hull, they are not relished by chickens, and for this reason they are somewhat indigestible. When ground they are used pretty freely in mash food; also the rolled and granulated oatmeals are used for feeding young chicks. The ground oat, without the hull, is used extensively for fattening fowl.

Barley, either whole or ground, is very good. It has rather too much hull; but otherwise it is a satisfactory food. It is considered by many to be next to wheat in point of value.

Buckwheat is very popular as an egg-producer, in districts where it is grown extensively. Some difficulty is at times experienced when first feeding it to fowls in getting them to eat it, but this is usually overcome in a day or so, if other feeds are withheld. Boiling the buckwheat will sometimes start the birds to eat it. After the birds once get accustomed to its appearance, it is much relished by them. Ground buckwheat is an excellent food to use in a fattening ration. It is somewhat like corn in its fattening properties and therefore it is better for winter than summer use.

Shorts and wheat bran are both used extensively in making mashes, or soft foods. They are excellent foods to use in maintaining the health of the flock.

The general method of feeding is to give a mash of mixed ground grains, moistened with water or milk, in the morning; a little whole grain scattered in the straw covering the floor, at noon; and all the whole grain they will eat at night. This latter meal is usually fed in the straw. Some poultrymen adopt the plan of not feeding the mash until evening. We have been practising this plan for some time, and we like it very well. The objection to the former plan is that the hen is likely to become gorged with food early in the morning, and thus take to the roost for the rest of the day, which is usually followed by hens becoming too fat, and the egg record becoming small; but notwithstanding, many successful poultrymen use this method to advantage. The objection to feeding the mash at night is that it becomes quickly digested, and the bird has not sufficient food to last it during the long winter night; but this objection can be overcome by giving a little whole grain after the mash at night.

Some poultrymen feed their fowls but twice a day, morning and evening, and get very good results; but I favor feeding three times a day. Our plan is somewhat as follows:

Early in the morning the fowls are given half a handful each of whole grain. This is buried in the litter on the floor. Thus the fowls get exercise (a very necessary thing) in searching for it and at the same time keep themselves warm. At noon about two handfuls of grain are given to a dozen hens in the litter; they are also given all the roots they will eat, either pulped or whole, as fowl relish mangels, sugar beets and turnips. Cabbage also—a very good green food—is sometimes given. About four o'clock in the afternoon they are fed a mash composed of equal parts of bran, shorts, oat-chop and corn-meal (during cold weather); and to this is added about 10 per cent. of animal meal, if we have not cut, green bone or cooked meat. These foods are thoroughly mixed together in the dry state, after which is added steeped clover, which has been prepared by getting a bucket of clover leaves, or cut clover hay, and scalding it with boiling water. This is done early in the morning, and the bucket is kept covered with a thick sack throughout the day. This will be quite warm at night, if it has been kept in a warm place. There is usually sufficient liquid to moisten the meal that has been mixed. Our aim is to have about one-third of the ration, in bulk, of clover. After the mash a small amount of whole grain is fed in the straw. There is—and should be —a plentiful supply of good, *pure water within easy reach at all times.*

## NATURAL AND ARTIFICIAL INCUBATION.

Whether it will pay to buy incubators and brooders depends largely on one's circumstances. Where chicks are wanted in considerable numbers earlier than April 15th, an incubator becomes practically a necessity, as it is seldom that hens become broody in numbers until after the 1st of April. Again, where one wishes to hatch more than 150 chicks, an incubator is in many cases cheaper and better than the natural method. It is also a necessity where one is breeding from the non-setting varieties.

There are numerous illustrations of chicks being raised in large numbers by the natural method in the States of Rhode Island and Massachusetts, particularly in the former State. Where this method is followed, the chicks are hatched largely during the months of May and June; and where from 500 to 1,500 laying hens are kept, there is little difficulty in getting a sufficient number of broody hens. Those who are keeping large numbers of hens appear to be well satisfied with the natural method; but there can be no doubt that the number of incubators in use is increasing from year to year.

*Hen and Incubator.* As to results, I am of the opinion that *on the average*, the incubator will hatch as many chicks as the hen. There is no doubt that some individual hens hatch a much higher percentage than a machine; but when we put 240 eggs into a machine and the same number under 20 hens, our experience is that we get about equal results in the number of chicks hatched.

The average hatch is probably one chicken from every two eggs set. This, of course, varies with the different seasons, also with the percentage of fertile eggs, and the strength of the germ. We have found during the months of February and March, when the ground is covered with snow and the fowls are closely housed, that the percentage of fertile eggs is small, and that the germs are very weak. Under such conditions we have very poor hatches and chicks that are very hard to rear. Much better eggs are obtained in December and early January, or when the fowls get out into the fresh air and are able to pick some grass. Thus it will be seen that, as a general rule, as the percentage of fertile eggs increases, the vitality of the germ increases, the percentage hatched is larger and the mortality among the young chicks smaller. For example, we would expect to get a much larger percentage hatch of the fertile eggs from eggs that were 90 per cent. fertile than from those that were 60 per cent fertile; and, moreover, we would figure on raising a much larger percentage of chicks from the former eggs than from the latter, owing to the chicks being stronger and having greater vitality.

*Setting the Hen.* It is generally agreed that, in order to secure a good hatch, the hen must be placed where other hens are not likely to disturb her; for, as a rule. we seldom get good hatches where other hens lay in the nest with the sitter. Some farmers do not set a hen until one becomes broody on a nest where no others lay, which often necessitates late chicks. The difficulty can be overcome by making a new nest for the broody hen. Get a box about 12 inches square and 6 inches deep; put some earth, or an overturned sod, in the bottom, taking care to have the corners very full so that no eggs can roll out from the hen and get chilled; next put on about two inches of straw or chaff; and then put a few earthen eggs into the nest. Place the nest in some pen where nothing can disturb the hen, and put her on after dark. Feed and water must be within easy reach and a dust-bath should also be convenient. If the hen is sitting quiet the next day, you will be safe in putting the eggs under her. In our experience we get 90 per cent. of the hens to sit by following this method.

It should be remembered that the hen will be in better condition if dusted with insect powder when set, and also a few days before the hatch comes off. This will usually keep the lice in check, especially if some tansy or mint leaves are used in making the nest.

When hens are to be set in large numbers, I know of no better method than that adopted by the Rhode Island farmers. Early in the spring, the hens are set in any old outbuilding; later on they are set as seen in the cut, that is, the nests are stacked tier upon tier; a few boards serve as a shelter; and the wire run gives room for some green food, a dust bath, etc. The hens are generally let off to feed and water every other day. It is considered advisable to have an attendant present to see that the hens get back to the proper nests; also to prevent their fighting.

*Incubators.* There is really very little known about the running of incubators. Some people succeed in hatching a large percentage, while others, under exactly the same circumstances, fail. The exact reason why, we do not know. This much, however, can be said, the machine should not be placed in a direct draught, nor yet in a building where there is a lack of ventilation. Fresh air is one of the most important things in an incubator room. I have known machines to hatch well in well-ventilated cellars, kitchens, dining-rooms and bed-rooms. Hardly any two people agree as to which is the best place to operate the machine. As a general rule, it is wise to follow the manufacturer's directions. I find that different makes of incubators require different treatment, both as to temperature and otherwise, and we generally get the best results when running closely to the directions. Where possible, the temperature in the room should vary but little; for, if it varies 30 to 40 degrees in 24 hours, it is very hard to keep an even temperature in the machine; and it is absurd to expect that the machine will not vary with such changes in the surrounding temperature.

## REARING OF CHICKS.

Chickens hatched in an incubator can be reared either with hens or with a brooder. Some people are able to make good hatches with their incubators; but they are unable to rear the chickens in brooders. In this case I would advise the use of broody hens for mothers; and the same would apply to those who have an incubator, but do not care to invest in a brooder.

The best plan I know of to get the broody hens to take the chicks, is to give the hen two or three eggs out of the incubator on the 18th or 19th day and allow her to hatch them. When your incubator hatch is over take a dozen or fifteen chickens and put them under the hen after dark. Even if they happen to differ in color from those she has hatched, she will mother them all the same. If you give them to her in the day time she may not do so. Never neglect to give the hen a thorough dusting before giving her any eggs. If there is one thing more than another that requires careful attention in rearing young chickens, it is to keep them free from lice. If lice get upon them, from the hen or elsewhere, a large proportion of them will be almost sure to die.

There are many good brooders upon the market which are well described in the manufacturers' catalogues; hence a description here is unnecessary. Personally, I am in favor of a three-compartment brooder, as it admits of keeping the chicks in near the heat when young, and on stormy days. The brooder lamp should always be arranged so as to give little chance of fire.

If the brooder can be placed in a small portable house, it is a good plan, as the brooder is thus protected from stormy cold winds in the early spring; also from the heat later on. The house protects the chicks from rain, and serves as a roosting coop after they become too large to stay in the brooder.

Chicks should not be fed until they are at least 36 hours old. It is a serious mistake to feed them earlier. Too early feeding is the cause of indigestion and bowel trouble in many cases. We try to keep the temperature of the brooder between 90 and 95 degrees throughout the first week. After the first week the temperature is gradually lowered, generally speaking, about 1 degree a day. When the chicks are put into the brooder, it is well to remember that every 15 chicks will raise the temperature of the brooder 1 degree. Be careful not to get your brooder too hot, nor yet so cool as to chill the chicks. This is very important, especially during the first 10 days.

The floor should be covered with dry sand or clover chaff before the chicks are put into the brooder. Luke warm water should also be put into the brooder for drink just before the chickens are taken from the machine. I have had best success in starting young chicks on hard-boiled eggs, finely chopped, shell included, and bread crumbs —about 4 parts by weight of bread to one of eggs. This is fed dry. After the first two days we begin to give an occasional feed of seed chick-food, which is made as follows:

| | |
|---|---|
| Cracked wheat | 25 parts. |
| Granulated oat meal | 15 " |
| Millett seed | 12 " |
| Small cracked corn | 10 " |
| Small cracked peas | 6 " |
| Broken rice | 2 " |
| Rape seed | 1 " |
| Grit (chicken size) | 10 " |

This can be used for the first feed and continued through the first 8 to 10 weeks with good results. We aim to feed the chicks five times a day. Generally after the first few days, there are three feeds a day of this chick-food, one of bread and milk (the bread being squeezed dry and crumbled), and one of whole wheat, or a mash made of equal parts of bran, shorts and corn meal, to which has been added 10 per cent. of animal meal or blood meal. If we can secure fresh liver and get it boiled, this is generally given twice a week, and the animal meal is than omitted from the mash. If the chicks cannot get out to run about, the seed chick-food may be scattered in the chaff, and the little chicks will work away most of the day for it. This gives them exercise, which is a necessity in rearing chicks. If there is no green food to reach, it must be supplied. Lettuce is excellent. Sprouted grains are very good, as is also root sprout, cabbage, rape, etc.

When the chicks get to be about 8 weeks of age, we usually feed about three times a day—the mash food in the morning and whole wheat and cracked corn at noon and night. If we are anxious to

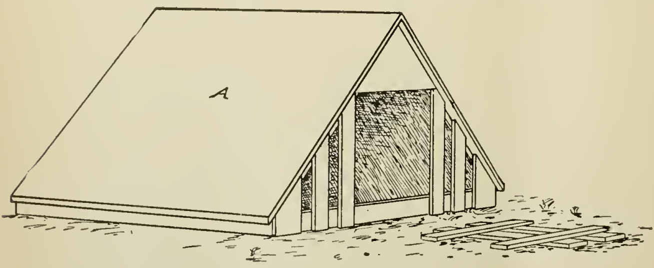


Fig. 11. Coop A.—Each side of roof 24 in. by 30 in.; bottom, 2 ft. 4 in.

force the chicks, we give two feeds of mash and increase the animal meal a little.

The chicks are taken from the brooders at from 6 to 8 weeks of age, according to the weather. A small coop (Fig. 11.) is set in front of the brooder, so that the chickens cannot get to the brooder entrance, the result being that they get into the coop A. After a day or two take away your brooder, and the coop can then be moved daily to fresh ground. This will keep the coop clean. When the chicks get too large for the coop A, which will be in about ten weeks, they are put into coop B. (Fig. 12.) The same process is gone through

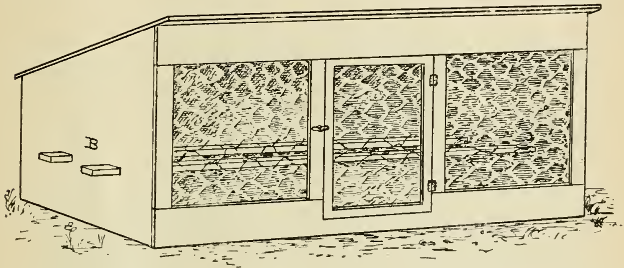


Fig. 12. Coop B.—Length, 6 ft.; width, 2 ft. 6 in.; height in front, 2 ft. 4 in.; height at back, 18 in.

with coop B. It is set in front of coop A, so as to obstruct the entrance; and the chicks then go into the coop B, and soon take to the roost. Coop B will roost 20 chicks until full grown. Try to keep your chickens roosting in the open air as long as possible. Never house them in close, stuffy houses. If you do they will be sure to go wrong, become weak, and be of little or no value, either as breeders or egg-producers.

## BREEDING MARKET FOWLS.

When looking over dressed poultry in some of the exporter's shops, I have often thought how easy it would be to improve the appearance of much of the ordinary poultry, and some of that which is specially fattened, if the birds were bred to a proper type. I have spent much time in examining different types of birds, alive and dressed, and in observing the feeding capacity of certain types; but it would take years to arrive at definite conclusions on these points. I am however of the opinion that one of the most important things to be sought after is *constitution*. This may have no actual market value, but it certainly has much to do with the bird's ability to grow and put on flesh. What we want is a good feeder, and an economical producer. Generally, a bird with a short, stout, well-curved beak, a broad head (not too long), and a bright, clear eye, has a good constitution. And I have noticed that when a bird has a long, narrow beak, a thin, long comb and head, and an eye somewhat sunken in the head, it is usually lacking in constitution. Such a bird is likely to have a narrow, long body and long legs, upon which it seldom stands straight. There are some exceptions to this rule; yet, generally speaking, if a bird has a good head, the chances are favorable for a good body; and, if it has a poor head the chances are against it. I have frequently noticed in the Rose-comb breeds, such as Wyandottes, that a good-shaped one is seldom found with a long, narrow comb.

Fig. 13.

The neck should be moderately short and stout, indicating vigor, The breast is the most important point in a market chicken. It should be broad, *moderately* deep; and, if broad, it will present a fine appearance and appear well-fleshed. It is quite possible that a broad, deep breast will carry more meat than a moderately deep breast of the same width ; yet there is no doubt but that the latter will present much the better appearance, and sell more quickly and at a higher price in the market.

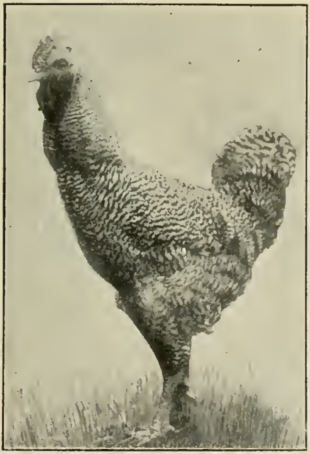

Fig. 14.

When considering the length of breast, we must try to have it come well forward (see Fig. 13), and not be cut off at an angle, as in Fig 14. The body, in general, should present the appearance of an oblong when the head, neck, and tail are removed.

Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 20.

Fig. 19.

We frequently see birds that are very flat in front, aud cut up behind, as in Fig. 15. Chickens of this class have a very short breast; and, if the breast happens to be deep, as it is in this bird, the chicken will have a very poor appearance when dressed, as it will show a marked lack of width and length of breast, with excessive depth. (Notice that the head is narrow and long, the body is narrow, the eye is bright but slightly sunken, the legs are long and not straight under the body).

In Fig. 14 observe the very flat breast, the length of back, the long neck and head, the narrow comb, the sunken eye, and the length of legs. The breast comes fairly well back, but not well forward.

In Fig. 13, the bill is short and stout, but not so well curved as it should be. Note the breadth of head, the prominence and brightness of the eye, the short, stout neck, the great width of the breast, the fulness caused largely by the breast bone extending well forward, the short, stout legs (straight under the body), and the width between the legs. There is an expression about this chicken that indicates health and the essence of vigor.

The back should be broad, to give lung and heart capacity ; and the width should extend well back to the tail-head. We do not want the wedge-shaped back, as seen in some fowls that have great width at the shoulders and taper rapidly towards the tail-head.

It is much easier to get good-shaped market pullets than good cockerels. The market demands a five-pound bird when dressed, and farmers have gone into raising big chickens. To that end they are asking for large, overgrown cockerels, of excessive depth, for breeders ; and the result is that we get dressed chickens weighing four to five pounds each, that have immense, high breast-bones and very long legs. These are not attractive to the buyers, and they sell at less price per pound than plumper birds. For example, if given two birds of the same width of breast, one is one and one-half inches deeper in the breast than the other. The result will be that one bird will look plump and sell readily, while the other will lack in plumpness and be slow in selling. This lack of plumpness can be bred out by using such males as that shown in Fig. 13.

We like to have birds as well built as we can get them; and Fig. 13 is as near the ideal market chicken as we have in the breed which he represents.

The hen, as seen in Fig. 16, is of a good market type. (Note the width and fulness of breast). As a breeder, she is a little fine in bone, and rather too small. She has, however, that blocky appearance which is desirable.

Fig. 17 is a photo of a cross-bred chick (sire, Buff Orpington; dam, Houdan). Note the length and fulness of the breast; also good beak and eye.

Fig. 18 is a ten week's old son of Fig. 13. You will observe the same general characteristics as seen in the father—fair beak, good eye, excellent breast, both as to length and width, without excessive depth. The thigh is also medium in length.

Fig. 19 shows a good head throughout, very full and wide breast, and legs that stand well under the body and well apart. This bird is of the type we like to feed in the fattening crate.

Fig. 20 represents the long, narrow sort. (Note the long beak, the narrow head, the sunken eye, the long neck, and long crooked legs). When dressed, his appearance will not be pleasing.

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## TRAP-NEST.

Fig. 21 represents a trap-nest made by the college carpenter. This nest is very simple in construction. The door is adjusted low enough so that the hen on entering raises it slightly, thus relieving the hook, which drops back and allows the door to fall. This nest works well. The only objection to it is that the fowls using it require to be pretty much of the same size. A small hen may not raise the door enough to unfasten it.

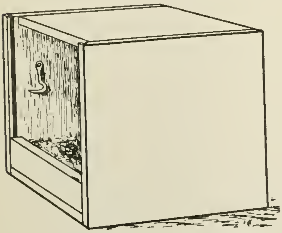

Fig. 21 (*a*). Showing hook which holds up the door. The nest is 12 inches wide, 12 inches high and 15 inches long.

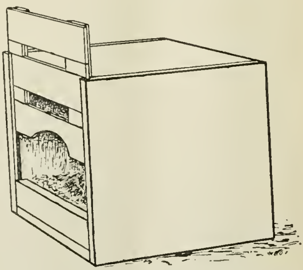

Fig. 21 (*b*). Nest set ready for the hen to enter.

Where one is anxious to build up a special strain of birds, either for special utility or for fancy exhibition purposes, the trap-nest, if looked after, will show what hens lay, and which hen lays certain eggs, thus enabling the breeder to know exactly what he is doing.

They require considerable time in the way of keeping records, and releasing hens after laying.

## FATTENING CHICKENS.

A number of experiments have been conducted in fattening chickens for the market. There is an unlimited market for well-fleshed fowls in England, and the demand at home is constantly increasing. Fatted chickens were on September 18th, 1903, selling for 13 cents per pound in Montreal, and the dealers could not get nearly as many as they wanted.

The English market requires a white-fleshed chicken, and our best home market also appears to favor this color of flesh. Black-feathered chickens, and those having black legs are not in favor.

There is little use in trying to fatten scrub stock. Good pure-bred males of such breeds as Plymouth Rocks, Wyandottes, and Orpingtons can be purchased at moderate prices, and these only should be used to breed from. Very large chickens are not in favor. What is required is a meaty bird weighing from four to five pounds. The breast should be especially well developed, and should be plump, as this is the most valuable part of the body.

### Construction of Fattening Crates.

Fattening crates are usually made 6 ft. 6 in. long, 18 to 20 in. high, and 16 in. wide. The crate is divided into three compartments, each holding from four to five birds, according to the size of the

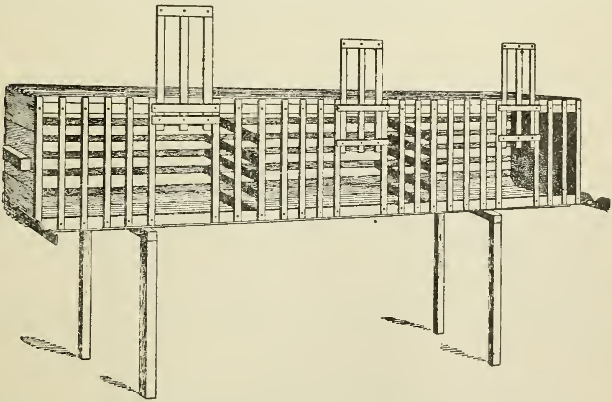

Fig. 22. Showing a single crate or coop.

chicken. The crate is made of slats, except the ends and partitions between the compartments, which are solid wood—those on the top bottom and back running lengthwise of the coop, while those on the front run up and down. The slats are usually 1½ inches wide and

$\frac{5}{8}$ inches thick. Those in front are placed 2 in. apart to allow the chickens to put their heads through for feeding. The slats on the bottom are placed about $\frac{3}{4}$ inch apart, so as to admit of the droppings passing through to the ground. Care should be taken not to have the first bottom slat at the back fit closely against the back. An opening between the first slat and the back prevents the droppings from collecting and decomposing. The slats on the top and back are usually 2 inches apart.

There is a small V-shaped trough arranged in front of the coop for feeding and watering the chickens. This trough is from 2 to 3 inches deep and is generally made of $\frac{3}{4}$ inch lumber.

Very fair coops may be made from old packing boxes, by taking off the front and bottom, and subsituting slats in their places, (see Fig. 22). During warm weather, these crates may be placed out of doors. They need to be protected from the rain which is easily accomplished by placing a few boards over them. In cold weather the crates should be placed in a house or shed where they are protected from raw, cold winds. When fattening chickens inside of a building, it is well to darken the building and keep the birds as quiet as possible.

After each lot of birds is killed, we paint the crates with some liquid lice-killer. Coal-oil and carbolic acid is very good. Use one gallon of coal-oil to one pint of crude acid. We have used some of the prepared mixtures with good results. If the birds (bought from different parties) are very lousy when put up, they should be well dusted with sulphur. The birds should be watered at least twice every day in warm weather. Grit should be given them twice a week.

During the first week, feed lightly,—never quite all the birds will eat. I prefer feeding three times a day during the first week, and twice a day during the succeeding weeks. It seldom pays to feed the birds longer than three or four weeks. Chickens weighing from three to three and one-half pounds each, that are thrifty and of good breeding appear to be the most profitable for feeding. Large chickens, weighing from five to six pounds, gain less and eat more than smaller ones.

Should a bird become sick in the crate, I find that if it is given a teaspoonful of salts and turned out on a grass run it will usually recover.

### Cramming Machine.

The crammer consists of a food reservoir, to the bottom of which is attached a small force-pump moved by a lever and treadle which is worked by the foot of the operator.

Communicating with the pump is a nozzle, through which the food passes to the bird.

"A" is the food reservoir; "B," the pump; "E," the pump rod; "O," the lever, which on being depressed at the lettered end, causes the pump rod "E," to which it is attached, to move downwards, and to eject the contents of the pump "B" out of the nozzle "K." On relieving the pressure at "O," the lever and the parts connected therewith are drawn up by the spring "C," until the motion is arrested by a stop "M," which serves to determine the quantity of food ejected at each depression of the tread'e.

The charge may also be varied by arresting the pressure at any point in the downward thrust of the lever "O."

The illustration (Fig. 23) shows one method of operating with this crammer, and this plan is now largely followed in some parts of Sussex, England.


Fig. 23. Cramming machine for the forced feeding of chickens, turkeys, etc.

## Kind of Food Used in Cramming Machine.

Not all kinds of foods can be used in the machine. The food must be in a semi-liquid condition in order to pass through the machine. This necessitates the use of some kind of grain that will stay in suspension in the milk, beef broth, or whatever liquid is used in mixing the grain. Finely ground oats, with the hulls removed, or shorts, answer the purpose well. We use almost entirely the former food. Grain like corn-chop, or barley meal, are not suitable, as they sink to the bottom of the hopper and clog the machine. When cooked they work well, but are not good foods as is shown by experiments conducted here—see page 33.

The food is mixed to the consistency of ordinary gruel, or until it drips from the end of a stick.

### Will it pay to buy a Cramming Machine?

For the ordinary person, I think not. First-class chickens may be had by feeding in the crate from the trough only; indeed, I have had equally fleshy birds that have been fed for four weeks from the trough as where we have fed them two weeks from the trough and one week from the machine.

Where one has a special trade for high-class poultry, I am of the opinion that a more uniform product can be secured by using the machine. Machine-fed birds should realize at least one cent more per pound than trough-fed birds in order to pay for the extra labor, etc.

Birds that are fairly well fleshed when put into the crate will do better if put at once on the machine, instead of being crate-fed first.

### Fattening Chickens in July.

Early in July, several groups of chickens were put in crates for fattening. The results are given below:

Lot I. consisted of 12 Barred Rock cockerels weighing, when put up in crate, a total of 37 pounds.

| | Lbs. Grain Consumed. | Lbs. Skim-milk Consumed. | Lbs. Gain. | Lbs. of grain to make 1 lb. Gain. | Average gain per bird in 4 weeks. |
|---|---|---|---|---|---|
| First week | 17 | 25 | 9 | 1.8 | |
| Second week | 24½ | 31 | 5 | 4.8 | |
| Third week | 20 | 30 | 8 | 2.5 | 2.1 lbs. |
| Fourth week | 22 | 33 | 4 | 5.5 | |

Average of grain per lb. of gain in 4 weeks......3.2 lbs.

They were sold to a Montreal firm at 15 cents per pound f.o.b. here.

These chickens were rather leggy, and had high breast bones, and would have dressed much better when they had reached a weight of 6 or 7 pounds.

Lot II. consisted of 8 high-grade Leghorns, weighing a total of $18\frac{1}{4}$ pounds.

| | Lbs. Grain Consumed. | Lbs. Skim-milk Consumed. | Lbs. Gain. | Lbs. of grain to make 1 lb. Gain. | Average gain per bird in 4 weeks. |
|---|---|---|---|---|---|
| First week ........ | 7 | 10 | 4 | 1.8 | |
| Second week............ | 11 | 16 | $1\frac{1}{2}$ | 7.3 | |
| Third week ............. | 10 | 15 | 3 | 3.33 | 1.28 lbs. |
| Fourth week............ | 7 | 10 | $1\frac{3}{4}$ | 4. | |

Average of grain per lb. gain in 4 weeks....3.4 lbs.

When dressed these chickens were somewhat plumper than the Rocks owing to their being mature, but they were rather small. They were sold at 13 cents per pound.

Lot III. consisted of 20 Pit Game Crosses, weighing 40 pounds.

| | Lbs. Grain Consumed. | Lbs. Skim-milk Consumed. | Lbs. Gain per week. | Lbs Grain to make 1 lb. gain. | Average gain per bird in 4 weeks. |
|---|---|---|---|---|---|
| First week ... ......... | 24 | 36 | $9\frac{1}{2}$ | 2.6 | |
| Second week ..... .... | 27 | 41 | 9 | 3. | |
| Third week ...... .. .. | 29 | 44 | 14 | 2. | |
| Fourth week...... ..... | 30 | 45 | 3 | 10. | 1.77 lbs. |

Average amount of grain per lb. of gain in 4 weeks....3.1 lbs.

These chickens dressed fairly well, the breasts being rather plump; but they had an excessive length of legs and neck. They were sold at 15 cents per pound.

All the lots were fed three times a day on the following rations:

| | |
|---|---|
| Barley Meal................................ | 2 parts, |
| Corn Meal, or Chop ......................... | 2 " |
| Shorts or Middlings ......................... | 2 " |
| Finely Ground Oats ......................... | 1 " |
| Animal Meal ................................ | 1 " |

This mixture was used with about one and one-half times its weight of skim-milk.

## Feeding All-Cooked Food.

We found it impossible to buy finely ground oats during the latter part of August, so we tried cooking rolled oats, barley, and corn-meal. The grains were used in the proportion of 50 per cent. of rolled oats and 25 per cent. each of barley and corn. These foods could not be used in the cramming machine without first being cooked.

Two groups of 12 birds were fed from the trough, one group for two weeks and the other only one week, with the following results:

Group I. consisted of 12 grade Plymouth Rock cockerels. They weighed when placed in the crates a total of 35¾ pounds. During the two weeks they consumed 103 pounds of cooked food, or equal to about 34 pounds of uncooked grain. They made a gain of five pounds. At the end of the two weeks the birds were very thin and sickly, their digestion being very bad. One of them died. The others were turned out on a grass run, and two of them died the second day they were out. The remainder are beginning to pick up again.

Another lot of 12 Rock chickens, weighing a total of 62 pounds, which had been fed the previous week on raw food, were given cooked food. During the week they were fed on cooked food they lost in weight, and three of them became so sick that they died. The remaining nine were placed on uncooked food the next week, and put on more than three-quarters of a pound each.

Two hundred chickens were crammed with cooked food. A few of the birds gained slightly, but the majority of them lost in weight. After having been fed in this manner for one week, a few of the best were shipped to a Toronto dealer, who complained about there being no meat on the breast. They sold for 9 cents per pound, live weight, while chickens fed on raw food sold for 13 cents per pound. The remaining birds were turned loose on a grass run.

The chief difficulty with the cooked food appears to be that it damages the chicken's digestion. Many of the birds that were put out on the grass run after being fed on cooked food have not recovered yet— three weeks after being turned out.

Cooked food can no doubt be fed to advantage in conjunction with raw food, but an all-cooked ration that is of a forcing nature appears to be entirely unsuitable for fattening fowls.

## Grain Rations.

The following table shows the amount of feed consumed by the different groups of chickens, the cost of producing a pound of gain, and the number of pounds of grain it took to make one pound of gain.

| Grain Rations. | | No. of trials. | Weight when put in crates. | After two weeks' feeding. | Gain. | Grain consumed. | No. of pounds of grain to make 1 lb. gain. | Milk consumed. | Cost of pound of gain. |
|---|---|---|---|---|---|---|---|---|---|
| GROUP I— | | | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. | lbs. |
| Cornmeal, 5 parts..... Shorts, 4 parts........ Pearl oat dust, 1 part. Animal meal, 1 part.. | Cost per cwt., $1.10 | First trial | 43 | 55 | 12 | 35 | 2.916 | 35 | 3.5 |
| | | Second " | 48.5 | 59.5 | 11 | 39 | 3.54 | 39 | 4.263 |
| | | Third " | 49.5 | 61 | 11.5 | 38 | 3.3 | 38 | 3.974 |
| | | Average | 47 | 58.5 | 11.5 | 37.38 | 3.252 | 37.33 | 3.912 |
| GROUP II— | | | | | | | | | |
| Cornmeal. 2 parts .... Ground buckw't, 2 prts Pearl oat dust, 1 part. | Cost per cwt., $1.23 | *First trial | ...... | .... | .... | ... | ...... | ...... | ..... |
| | | Second " | 48.5 | 65 | 15.5 | 42 | 2.54 | 42 | 3.363 |
| | | Third " | 48 | 63 | 15 | 40.5 | 2.7 | 41 | 3.56 |
| | | Average | 48.25 | 64 | 15.75 | 41.25 | 2.62 | 41.5 | 3.461 |
| GROUP III— | | | | | | | | | |
| Cornmeal, 4 parts ... Ground buckw't, 2 prts Pearl oat dust, 2 parts. | Cost per cwt., $1.22½. | First trial | 45 | 53 | 8 | 35 | 4 375 | 35 | 5.797 |
| | | Second " | 47.5 | 63 | 15 | 41 | 2.66 | 41 | 3.63 |
| | | Third " | 50 | 62 | 12 | 40 | 3.3 | 40 | 4.416 |
| | | Average | 47.5 | 59.33 | 11.66 | 38.66 | 3.445 | 38.66 | 4.614 |
| GROUP IV— | | | | | | | | | |
| Cornmeal, 2 parts..... Pearl oat dust, 1 part. | Cost per cwt., $1.23 | First trial | 48 | 53.5 | 5.5 | 34.5 | 6.27 | 35 | 8.34 |
| | | Second " | 48 | 60 | 12 | 38 | 3.18 | 38 | 4.22 |
| | | Third " | 48 | 58.5 | 10.5 | 37 | 3.52 | 37 | 4.686 |
| | | Average | 48 | 57.33 | 9.33 | 36.5 | 4.32 | 36.66 | 5.748 |
| GROUP V— | | | | | | | | | |
| Pearl oat dust—cost per cwt, $1.50 | | First trial | 48 | 60 | 12 | 34 | 2.83 | 34 | 4.83 |
| | | Second " | 49 | 63 | 14 | 40 | 2 85 | 40 | 4.57 |
| | | Third " | 47.5 | 60 | 12.5 | 40 | 3.2 | 40 | 5.12 |
| | | Average | 48.166 | 61 | 12.83 | 38 | 2.96 | 38 | 4.84 |

* This food was not used in the first trial.

The following prices were paid for grain: Corn meal, $1.10 per cwt.; ground buckwheat, $1.20 per cwt.; middlings or shorts, 90c per cwt.; animal meal, $1.60 per cwt. There were 12 birds in each trial of each group. The last ten days of the feeding the birds were fed from the cramming machine, one and one-half pounds of milk being used to one pound of grain.

## CONCLUSION.

Ration No. 1 is a good economical producer, but is objectionable, because it has a tendency to produce yellow flesh, which is undesirable in our best market.

Ration No. 2 is, perhaps, the most palatable of any, and it is one that makes a nice white flesh at a moderate cost.

Ration No. 3 is much the same as No. 2, except that it contains more corn-meal, which tends to make it less adapted for use during warm weather. Note the results of the first trial. It has a slight tendency towards producing a creamy flesh.

Ration No. 4 is the most unsatisfactory of all. The excess of corn in it decreases its palatability, and also makes it unsuitable for feeding during warm weather.

Ration No. 5 is a good one, when the oats can be purchased at moderate prices. I am of the opinion that rations Nos. 2 and 5 are both excellent, and which it would be advisable to use would depend largely upon the prices of the different grains.

Result of one Experiment with Chickens of Different Weights Fed by Different Methods—Experiment began October 2, 1901.

| Groups,—12 birds in each. | Grain fed during the first 2 weeks. | Milk fed. | Cost of feed for first 2 weeks. | Gain in 2 weeks. | Cost of 1 pound of gain. | Feed used during the last 10 days. | Milk used. | Gain during last 10 days. | Cost of food for last 10 days. | Cost of one pound of gain. | Total cost for 24 days' feeding. | Total gain during 24 days. | Cost of one pound of gain (24 days) | Selling price per pound. | How fed. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lb. | lb. | cts. | lb. | cts. | lb. | lb. | lb. | cts. | cts. | cts. | lb. | cts. | cts. | |
| No. 10. Average weight 3½ lbs. each (when put up to feed) | 41 | 41 | 54.12 | 12 | 4.51 | 30 | 30 | 3 | 39.6 | 13.2 | 93.72 | 15 | 6.248 | 10 | Fed in the fattening crates from the trough only. |
| No. 4. Average weight 2¾ lbs. each. | 34 | 34 | 46.2 | 11.25 | 4.11 | 27 | 27 | 6 | 35.64 | 5.94 | 81.84 | 17.25 | 4.74 | 10 | Fed in the fattening crates from the trough only. |
| No. 20. Average weight 4⅓ lbs. each. | 47.5 | 48 | 62.75 | 11 5 | 5.45 | 40 | 40 | 6 | 52.80 | 8.8 | 115.55 | 17.5 | 6.60 | 10 | Fed in the fattening crates from the trough only. |
| No. 11. Average weight 3½ lbs. each. | 40 | 40 | 52.80 | 12.75 | 4.14 | 36 | 48 | 9 | 53.40 | 5.93 | 106.22 | 21.75 | 4.88 | 11 | Fed for the first two weeks in the fattening crates from the trough; the last 10 days from the machine. |
| No. 3. Average weight 2¾ lbs. each. | 35.25 | 35 | 46.2 | 11 | 4.2 | 32 | 48 | *5⅓ | 48.02 | 8.72 | 94.22 | 16.5 | 5.71 | 11 | Fed for the first two weeks in the fattening crates from the trough only; the last 10 days by the machine. |
| No. 21. Average weight 4⅓ lbs. each. | 44 | 48 | 63.36 | 11.75 | 5.39 | 44 | 66 | 11 | 66 | 6 | 129 36 | 22.75 | 5.68 | 11 | Fed in the fattening crates the first two weeks from the trough only; last 10 days from the machine. |
| No. 12. Average weight 3½ lbs. each. | 38 | 38 | 50.16 | 8 | 6.27 | 24 | 24 | 3 | 31.68 | 10.55 | 81.84 | 11 | 7.44 | 9 | Fed in a pen, each bird having about 5 square feet of floor space. |
| No. 2. Average weight 2¾ lbs. each. | 34 | 34 | 44.88 | 6.75 | 6.65 | 23.5 | 24 | 3 | 31.07 | 10.36 | 75.95 | 9.75 | 7.78 | 9 | Fed in a pen, each bird having about 5 square feet floor space. |
| No. 22. Average weight 4⅓ lbs. each. | 41 | 41 | 54.12 | 8.5 | 6.367 | 26 | 28 | 4 | 34.32 | 8.58 | 88.44 | 12.5 | 7.07 | 9 | Fed in a pen, each bird having about 5 square feet of floor space. |

*One bird in this group died, apparently not being able to stand feeding by the machine.

### General Conclusions.

1. It is evident from these experiments that chickens that are being fattened, produce a pound of gain at a less cost when fed in crates than when allowed to run at large in a pen.

2. That the birds fed in the crates from the trough and the cramming machine in addition produced a pound of gain at the least cost, the food consumed being taken into account only.

3. That feeding chickens in a pen loose, is not to be commended when the object is to fatten or flesh them for market purpose.

4. There is a slight difference in favor of a chicken weighing less than four pounds.

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## DRESSING AND SHIPPING POULTRY.

All fowls should be fasted from twenty-four to thirty-six hours before killing. Where this is not done, the food decomposes in the crop and intestines, the result being that the flesh becomes tainted and does not keep well.

There are two methods of killing that are considered proper. One is to kill by bleeding, which is accomplished by making a deep incision with a sharp knife in the roof of the mouth, immediately below the eyes. This method is considered to be the better one in

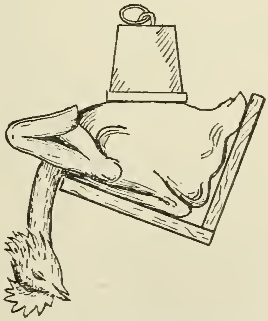

Fig. 24. A chicken weighted in shaping board. (Lewis Wright.)

the Eastern States and also in some parts of Canada. The other method is to kill the bird by wringing or pulling the neck. This is done by taking the chicken in the hands, stretching the neck, holding the crown of the head in the palm of the hand, and giving a quick turn backward and at the same time a steady pull. This method is favored by the exporters of dressed fowls, and is much cleaner than bleeding the fowls. It is claimed by the exporters that the flesh will keep longer and will not be so dry as where the birds are bled. I prefer the latter method.

After the bird is killed, plucking should begin at once. Care should be taken to keep the head downward, to allow the blood to collect in the neck. Where the birds are allowed to become cool before being plucked, it is very hard to avoid tearing the skin; and the plucking is much more tedious. The birds should be plucked clean with the exception of about two inches of feathers adjoining the head.

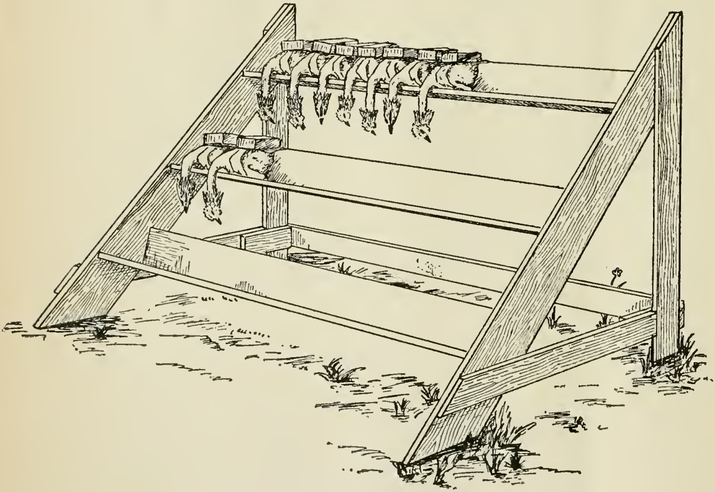

Fig. 25. Showing a number of chickens in the shaping boards.

After the chicken has been plucked, it should be placed on a shaping board, as seen in Figs. 24 and 25. The weight placed on the top of the chicken is used to give it a compact appearance. This weight may be of iron, as seen in the cut, or a brick may be used in its place. If chickens are hung by the legs after being plucked, it spoils their appearance, making them look thin and leggy.

Many good chickens are spoiled by being packed before they are thoroughly cooled. Care should be taken that all the animal heat is out of the body before the fowls are packed. We always cool the birds at least twelve hours before packing them.

The chickens are packed in boxes as seen in Fig. 26. The box is lined with parchment paper; and, if the chickens are to be shipped a long distance, each bird is wrapped in paper. This prevents the chickens from bruising each other, and at the same time, to a considerable extent, checks decomposition. Do not use ordinary wrapping paper, as it draws dampness, and will cause the chickens to become clamy, which makes them more or less unsaleable.

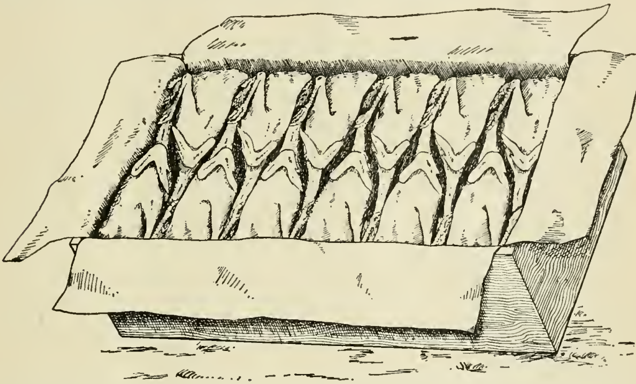

Fig. 26. Showing the top layer of chickens in a shipping case as used for local trade. This is one system of packing dressed poultry. The boxes are usually made 3 feet long, 17 inches wide and 7 inches deep for 24 chickens weighing about 5 pounds each.

There are several other kinds of boxes used for shipping poultry. Nearly every exporter has his own shape of box, and his own method of packing. For shipping locally, we use a box three feet long, twelve inches wide, and twelve inches deep. The chickens are packed similar to those seen in Fig. 26, with the exception that they are three tiers deep. The box will hold thirty-six 4½-pound chickens. The boxes are made strong so that we can have the dealer return them to be refilled. Do not use cedar in the construction of the boxes, as in some cases it taints the flesh. Basswood or spruce answers well.

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## EGG PRESERVATION.

Several methods of preserving eggs were tested in our Poultry department during the year of 1900. The eggs for this purpose were taken early in June, and were tested in December. Many of the same methods that proved fairly successful in previous years were again tried.

*Method No. 1.* A solution composed of one part water glass (sodium silicate) and five parts water that had been previously boiled. This was a very strong solution, and unless an egg was absolutely fresh it would not sink in the solution.

The eggs from this solution were of fairly good flavor, and all were well preserved.

*Method No. 2.* This was similar to No. 1, except that eight parts of water were used instead of five parts. The eggs in this were nearly as good eggs as those in No. 1. This is a good preservative where it is desired to keep summer eggs for winter use.

*Method No. 3.* This was composed of ten parts of water to one part of water glass. There were no bad eggs in this solution, but the eggs were inferior in flavor and in poaching quality to those kept by methods No. 1 and No. 2.

*Method No. 4.* This consisted of the same solution as No. 2; but in place of allowing the eggs to remain in the liquid, they were removed after having been in it for a week, except the last lot, which was put into the solution. This lot was left in the solution for the remainder of the season.

(*a*) The eggs, after being in the solution for a week, were removed and placed in an ordinary egg case in the cellar. They were all good when tested, but had evaporated considerably and were lacking in flavor.

(*b*) These were the second lot of eggs to be placed in the liquid. They were handled similarly to those in (*a*), and were of about equal quality.

(*c*) These eggs were allowed to remain in liquid. They were well preserved, all being good.

They were scarcely equal in quality to those from No. 2 method, but were superior to those from No. 3.

*Method No. 5.* A lime solution made as follows:

Two pounds of fresh lime were slacked in a pail and a pint of salt was added thereto. After mixing, the contents of the pail were put into a tub containing four gallons of water. This was well stirred and left to settle. Then it was stirred thoroughly the second time and left to settle; after which the clear liquid was poured over the eggs, which had previously been placed in a crock or tub. Only the clear liquid was used.

These eggs were well preserved; but those from the bottom of the tub had a decidedly limey taste, and the yolk in them was somewhat hardened.

## ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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| Serial No. | Date. | | Title. | Author. |
|---|---|---|---|---|
| 101 | April | 1896 | Dairy Bulletin (out of print, see No. 114) | Dairy School O.A.C. |
| 102 | May | 1896 | Experiments in Cheesemaking | H. H. Dean |
| 103 | Aug. | 1896 | Experiments with Winter Wheat | C. A. Zavitz |
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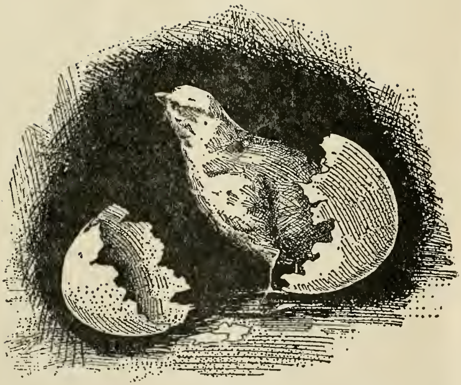
| 105 | April | 1897 | Instructions in Spraying (out of print, see No. 122) | J. H. Panton |
| 106 | June | 1897 | The San Jose Scale | J. H. Panton |
| 107 | May | 1898 | Dairy Bulletin (out of print, see No. 114) | Dairy School |
| 108 | Aug. | 1898 | Experiments with Winter Wheat | C. A. Zavitz |
| 109 | Sept. | 1898 | Farmyard Manure | G. E. Day |
| 110 | Jan. | 1900 | Experiments in Feeding Live Stock (out of print) | G. E. Day |
| 111 | Dec. | 1900 | Lucerne or Alfalfa | R. Harcourt |
| 112 | Dec. | 1900 | Foul Brood of Bees | F. C. Harrison |
| 113 | March | 1901 | Sugar Beet Experiments in Ontario | A. E. Shuttleworth |
| 114 | May | 1901 | Dairy Bulletin | Dairy School |
| 115 | July | 1901 | Comparative Values of Ontario Wheat for Bread-making Purposes | R. Harcourt. |
| | | | Notes on Varieties of Winter Wheat | C. A. Zavitz. |
| 116 | Aug. | 1901 | The Hessian Fly in Ontario | Wm. Lochhead |
| 117 | Jan. | 1902 | Pasteurization of Milk for Butter-making | H. H. Dean<br>F. C. Harrison |
| 118 | Jan. | 1902 | Yeast and its Household Use | F. C. Harrison |
| 119 | April | 1902 | Ventilation of Farm Stables and Dwellings | J. B. Reynolds |
| 120 | May | 1902 | Bitter Milk and Cheese | F. C. Harrison |
| 121 | June | 1902 | Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Rooms | H. H. Dean<br>F. C. Harrison |
| 122 | June | 1902 | Spray Calendar | Wm. Lochhead |
| 123 | July | 1902 | Cold Storage of Fruit | J. B. Reynolds<br>H. L. Hutt |
| 124 | Dec. | 1902 | Nature Study, or Stories in Agriculture | Staff, O. A. C. |
| 125 | Dec. | 1902 | Roup (A Disease of Poultry) | F. C. Harrison<br>H. Streit |
| 126 | April | 1903 | Peas and the Pea Weevil | C. A. Zavitz<br>Wm. Lochhead |
| 127 | May | 1903 | Farm Poultry | W. R. Graham |



## INTRODUCTION TO REVISED BULLETIN.

The exhaustion of the large edition of the "*Weeds of Ontario*," prepared by Professor Harrison in 1899 called for the publication of a new edition. On account of the increasing demand for information regarding *weed-seeds*, it was deemed advisable to incorporate into this revised bulletin some information regarding the identification of the common weed-seed impurities which are found in commercial clover and timothy seed. A few additional weeds are described, and the *methods of eradication* are in many cases given in greater detail. The drawings of the weeds on pages 87 to 89 and of the weed seeds on pages 7 to 13 were made by Mr. John Buchanan, B.S.A.; and much assistance was given by Mr. T. D. Jarvis, B.S.A., Fellow in Biology at the O.A.C.

WM. LOCHHEAD.

BULLETIN 128. TORONTO, AUGUST, 1903.

Ontario Agricultural College and Experimental Farm.

# SOME COMMON ONTARIO WEEDS.

BY

F. C. HARRISON, Professor of Bacteriology, and WILLIAM LOCHHEAD, Professor of Biology.

A leading educational authority lately said he did not believe that one farmer in a dozen could give the generally accepted common names of twenty of our common weeds. Whether this be so or not, one thing is certain, viz., that noxious weeds are spreading very rapidly in the Province of Ontario, and farmers need all the information they can get in preventing further loss from this very serious hindrance to successful agriculture. Hence the preparation of this bulletin for the Committee on Economic Botany appointed by the Experimental Union in connection with the Ontario Agricultural College.

The writer wishes to express his thanks for the assistance rendered by Wm. McCallum, B.S.A., who has labored unremittingly in collecting plants and in arranging material; and to Norman Ross, B.S.A., for his exact and artistic pen-drawings of the plants found in the bulletin. Mr. Ross made the drawings from specimens collected in this vicinity and from photographs taken in the laboratory.

## WHY WEEDS ARE INJURIOUS.

A weed has been defined as any plant out of place; and, in that sense, a wheat plant in a field of turnips is a weed.

Most weeds do considerable, and some very much, injury to the crops in which they are found. They produce these effects in several ways:

1. *They absorb soil moisture.* The amount of water which is taken up by weeds and evaporated from the surface of the leaves is very great. For instance, an average Mustard plant pumps from the soil about fourteen ounces, or seven-tenths of a pint, per day; a sunflower, thirty-three ounces; and so on. The transpiration is generally in proportion to the surface of the leaf; but thin leaves transpire, or throw off water, more freely than fleshy ones. Consequently weeds having large leaf-surface draw from the soil and give off through the leaves a large amount of water, and thereby rob the surrounding plants. Many botanists consider this waste of moisture the most serious injury done by weeds.

2. *They use plant food.* Weeds naturally make use of the same food as the cultivated plants among which they grow. Consequently they deprive a crop of a large amount of the available nourishment; and

they rob the succeeding crop as well. For example, an analysis of the Russian Thistle by Snyder showed "that it contains from 12 to 17 per cent. as much nitrogen as there is in clover; and an ordinary thistle of this kind covering a square yard takes more potash and lime from the soil than two good crops of wheat from the same area."

3. *They shade, crowd, and choke useful plants.* Weeds often grow more vigorously than useful plants; and, as a consequence, they shade, or crowd, or partially choke the seedlings of the desired crop. Black Bindweed (Fig. 20), for instance, often covers completely a large part of the plants among which it grows.

4 *They increase the labour and expense of cleaning seed.* At best, it is difficult to clean many of the smaller seeds, such as clover, grass, and rape seed; and the difficulty is greatly increased when they are grown on a dirty farm. It is almost impossible to clean clover seed by winnowing. Hence the necessity that the land on which it grows be clean.

5. *They interfere with a regular rotation of crops.* A well balanced rotation of crops conserves the fertility of the soil; but it is often necessary to depart from such a rotation when noxious weeds get possession of the farm—to give undue attention to the growth of hoed crops, for instance, or almost omit a certain crop altogether for a time, as in the case of the oat crop on a farm overrun with wild oats.

6. *They harbor the spores of injurious fungi* Many of the rusts which attack grain crops find a resting place on weeds of the grass and other families, which preserve them through the fall, winter, and spring.

7. *Lastly, they offend the eye, or are, as we say, an eyesore to good farmers and all people of taste.* They also interfere with the use of mowers, binders, and other implements in taking off crops.

## Introduction and Spread of Weeds.

Most of the injurious weeds found in this Province have come directly or indirectly from other countries. They are brought in and conveyed from field to field and farm to farm in various ways:

1. *By the wind.* Seeds which are carried by the wind usually have tufts of fine silky hair attached to them. Such are the seeds of the Dandelion, Canada Thistle, Sow Thistle (annual and perennial), Willow Herb, and Cotton Grass. These and similar seeds are wafted to and fro, till they become attached to the soil and commence to grow. In some cases, as in the Dock and Wild Parsnip, the seeds are winged; in others the pod containing the seed has flat and extended edges, exposing much surface to the wind. The Penny Cress is an example of the latter.

Some weeds are rolled along the ground by the wind. To this class belong the Russian Thistle and the Tumbling weed of the Northwest. When these weeds ripen, they break off close to the ground; and being light, they are easily carried by the wind, especially on an open prairie, and the seeds drop out as the weed rolls from place to place.

An examination of snow drifts in Dakota, a few years ago, showed the presence of many weed seeds. Thirty-two seeds of nine species were found in two square feet of a drift. In the same place it was observed that a twenty-five mile wind carried wheat seed a distance of thirty rods in a minute.

Seeds which become sticky when wet often adhere to leaves, and go wherever the leaves are carried by the wind. This is true of the Plantain.

2. *By water.* Some seeds, especially those of aquatic plants, are distributed by water. Darwin maintained that many seeds, dropping into the sea or being washed in from the shore, might be carried nearly thousand miles by the movements of the water without injuring their vitality. Seeds which float on the surface of water are carried to and fro by the wind till they find a lodgment and begin to grow; and many, of various kinds, are carried from high to low ground and distributed far and near by the rills and streams which flow from mountain, hill, and upland after heavy rains and spring thaws. The common Speedwell and Ragweed are often distributed in this way.

3. *By birds and other animals.* Seeds are distributed by animals in a variety of ways. "It is estimated that about ten per cent. of all flowering plants possess seeds which are dispersed by means of barbed or cleaved processes." By these barbs or processes the seeds cling to the feathers of birds and the hairy coats of animals, and in this way are carried from place to place. To this class belong the Bur, Burdock, Hound's Tongue, Bedstraw, Cockle, and such like. And the seeds of some plants, such as Mistletoe and the Meadow Saffron, exude sticky substances which cause them to adhere to birds and other animals.

In the hardened earth taken from the feet of birds Darwin found a large number of seeds, many of which germinated; and it is undoubtedly true that seeds are often conveyed from one place to another in the dirt that clings to the feet of animals.

Seeds often pass through the stomachs of animals without being digested; and during their passage they are conveyed hither and thither by the animal and finally deposited, to grow and reproduce their kind, whether of weeds or useful plants. Every farmer knows the truth of this statement as regards cattle, horses and swine; and it may be mentioned that Darwin picked from the excrement of small birds twelve kinds of seeds which were perfect in form and germinated in nearly every instance.

Ants, locusts, and other insects also, do something in the way of distributing the seeds of certain plants, including noxious weeds.

4. *By man.* Man himself, however, has most to do with the spread of troublesome weeds, chiefly through the agency of railroads, implements, farm yard manure, feed stuffs, and impure seed

Many weeds are carried from one province or country to another in the fodder and litter used by animals in transit on railways and in grain carried by rail. More or less of the grain, litter, and fodder are scattered at places along the track, and at stations where grain and animals are unloaded and cars cleaned out. Weeds thus get a start and spread to neighbouring farms. The Russian Thistle was introduced in this way.

The constant changing of implements, with dry earth, pieces of sod, etc., attached to them, from field to field, and from one farm to another, is a common method of spreading weed seeds all over farms and throughout whole neighborhoods; and threshing machines from dirty farms are well known sources of trouble under this head.

Fresh farmyard manure from city stables is very often full of weed seeds, and should be rotted or piled and allowed to heat thoroughly before it is applied to clean land. Wild lettuce, for example, was brought from Toronto to the neighborhood of Burlington in manure; and in this way many other pests have been distributed from towns and cities to the farms of the Province.

## A Few Facts Regarding Weed Seeds in Clover and Grass Seeds.

Of many hundreds of samples of commercial clover and grass seeds which were analyzed at the Agricultural College during the last two or three years, very few were free from noxious weed seeds. Many samples were *foul*, and there is no doubt that the sowing of an immense number of weed seeds accounts largely for the alarming spread of noxious weeds in recent years. The analyses made by the Department of Agriculture at Ottawa confirm those made at the College.

To give an idea of the *foulness* of many of the samples analyzed the following statements of some of the results may be valuable: In 1894, each of 12 samples of clover out of 60 contained 200 weed seeds to the ounce; another and the worst sample contained 9,080 weed seeds per ounce of clover seed. In 1902, fifty samples of clover and timothy were examined, and the percentage *purity* of the red clover seed ranged from 72 to 97 per cent. One sample contained 10,538 weed seeds per pound! In 1903, over 150 samples were examined, and the results were just as startling.

The following weed seeds were found in *common red clover*: rib-grass, curled dock, green foxtail, lamb's quarters, Canada thistle, white cockle, broad-leafed plantain, false flax, shepherd's purse, wormseed mustard, ragweed, mayweed, sheep sorrel, black medick, pepper grass, ox-eye daisy, and chicory.

In *white Dutch clover*: Broad-leafed plantain, pepper grass, rib-grass, may weed, sheep sorrel, yellow foxtail, and lamb's quarters.

In *crimson clover*: white cockle, pigeon weed, wild mustard, sheep sorrel, and poppy.

In *flax seed*: lamb's quarters, yellow foxtail, lady's thumb, white cockle, false flax, wild buckwheat, curled dock, wormseed mustard, burdock, wild mustard ragweed, hawkweed, and barnyard grass.

In *spring wheat* from the North-west: great ragweed, common ragweed, wild oats, corn cockle, wild buckwheat, and tumbling pigweed.

In *cultivated oats* exposed for sale: wormseed mustard, lamb's quarters, spiny sow thistle, night-flowering catchfly, lady's thumb, shepherd's purse, Canada thistle, sour dock, broad-leafed plantain, smartweed, pepper grass, wild tare, and black medick

In *alsike clover*: rib-grass, curled dock, sheep sorrel, broad-leafed plantain, false flax, foxtail, Canada thistle, white cockle, lamb's quarters, wormseed mustard, shepherd's purse, ox-eye daisy, night-flowering catchfly, mayweed, mouse-ear chickweed, lady's thumb, and sour dock.

In *timothy seed*: false flax, sheep sorrel, wormseed mustard, pepper grass, foxtail, rib-grass, shepherd's purse, curled dock, lamb's quarters, white cockle, Canada thistle, broad-leafed plantain, Norway cinque-foil, catnip, ox-eye daisy, spiny sow-thistle, night-flowering catchfly, mouse-ear chickweed, mayweed, pigweed, stickseed, horseweed, wild mint, corn cockle, chess, old witch grass, yellow avens, Kentucky blue grass, and ergot.

In the foregoing list the weed seeds are given in the order of relative abundance.

## Collection and Identification.

Not only every seedsman, but every farmer, and every teacher in a rural school, should have a collection of weed seeds for reference and comparison, in order that he may be able to detect and identify such seeds when they are in grass seed, clover seed, rape seed, or any other kind of seed which is sold or offered for sale. A good collection can be easily made in the summer months. All that is necessary is a number of small bottles and a little attention at the right time. The so-called homeopathic vials of one drachm capacity are suitable for the purpose, but they should be carefully and plainly labelled. If they are not so labelled, the collection will be valueless.

Descriptions of the Weed-seeds Illustrated on opposite page.

1. *Green Fox-Tail.* About one-twelfth of an inch long; oval with blunt ends; unequally bi-convex; brown and often mottled; surface granular and striate.

2. *Chess.* About one-third of an inch long; back rounded; glume 7-nerved; middle nerve projecting as an awn; the plate bears a row of spine-like hairs along each nerve.

3. *Wild Oat.* About three-fourths of an inch long; spindle-shaped; glume 9-nerved, middle nerve forming a twisted and bent awn; a tuft of brownish hairs arise from scar at base.

4. *Couch Grass.* Seeds about one-half inch in length; rather slender; oval; and tipped with a short awn.

5. *Curl Dock.* One-eighth to one-twelfth of an inch long; pointed elliptical, with three faces; surface smooth; reddish brown.

6. *Sheep Sorrel.* Seeds about one-twentieth of an inch in length; usually greyish or reddish brown, and finely roughened; provided with three equal faces, egg-shaped, each face of the cover of the seed bears central ridges with branches.

7. *Lamb's Quarters.* Circular, lens-shaped, and black; grooved on one face; often partially covered with the seed covering.

8. *Purslane.* One-twenty-fourth to one-twenty-fifth of an inch in diameter; jet black; flattened egg-shaped; notches at smaller end; surface finely roughened.

9. *Corn Cockle.* Seeds from one-twelfth to one-eighth of an inch long; angular in outline; color jet black, occasionally dark brown; each surface is crowded with ridges or spines arranged in circular rows leading from the scar.


The small drawings beside the enlarged drawings represent the natural size of the seeds.

## Descriptions of the Weed-seeds Illustrated on Opposite Page.

10. *Bladder Campion.* About one-sixteenth of an inch in length; kidney-shaped; surface roughened by many little projections arranged more or less in concentric rows; light brown in color.

11. *White Cockle.* Resembling Bladder Campion, but lighter in color; roundish and not so angular; depression about scar not so well marked.

12. *Night Flowering Catchfly.* Resembles white cockle.

13. *Pepper-Grass.* About one-sixteenth of an inch in length; egg-shaped but much flattened; the groove is curved and quite evident; the scar is white; reddish yellow to reddish brown.

14. *Penny Cress.* Seeds one-twelfth of an inch long; somewhat egg-shaped and flattened; surfaces have 12-14 curved ridges, which start and end at the pointed end of the seed; color dark reddish brown.

15. *Wild Mustard.* One-sixteenth of an inch in diameter; dark brown to reddish brown in color; almost spherical in outline.

16. *Worm Seed Mustard.* About one-twenty-fourth of an inch in length; most are pointed at the end opposite the scar; the groove is quite evident; surfaces smooth and dull; reddish yellow in color.

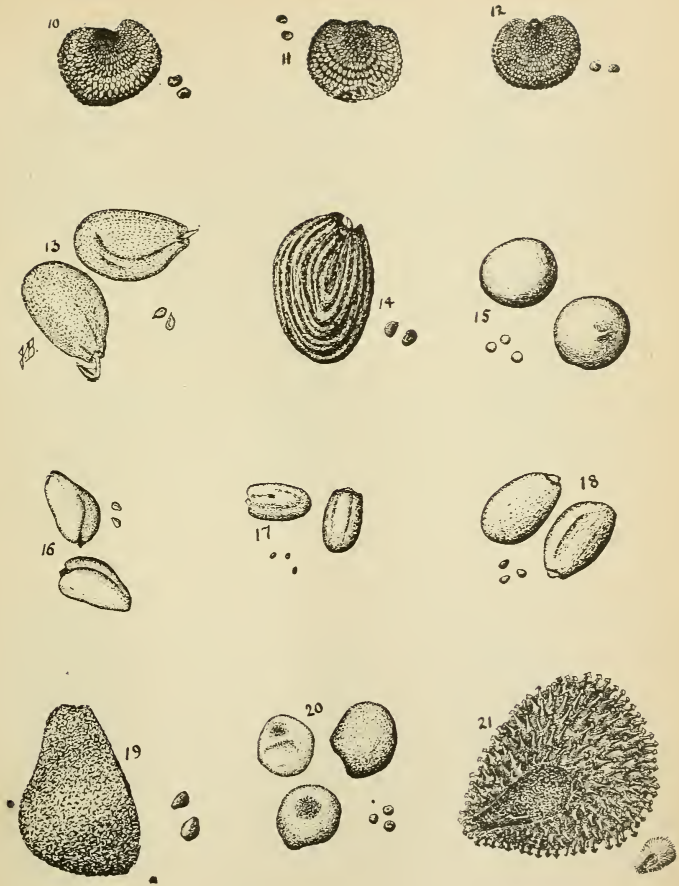
17. *Shepherd's Purse.* About one-twentieth of an inch in length; somewhat flattened; oval; each face has two grooves; color reddish yellow.

18. *False Flax.* Reddish brown; more or less oval and slightly flattened; about one-twentieth of an inch long; the groove more evident on one face than on the other; a whitish scar at one end.

19. *Field Bindweed.* About one-sixth of an inch long; oval; color dark brown; surface is somewhat roughened; outer face convex; inner face divided by a ridge into two plane faces.

20. *Dodder.* Ranging from one-sixteenth to one-twenty-fourth of an inch in length; slightly egg-shaped and flattened; notched near one end; resembles clover seed; color is yellow to dark brown and reddish.

21. *Hound's Tongue.* Seeds are spiny nutlets, one eighth of an inch long; upper side flat, oblique and roughened with hooked prickles.




The small drawings beside the large drawings represent the natural size of the seeds.

## Descriptions of the Weed-seeds Illustrated on Opposite Page.

22. *Blue Weed.* Stone-like in hardness; about one-tenth of an inch in length: surface roughened and of a gray color; the scar is large and triangular at flat end; the ridge along the outer face is convex.

23. *Mullein.* About one-twenty-fifth of an inch in length; thimble-shaped; base flat with scar at centre; thimble slightly six-sided, each side deeply pitted; pits of adjacent rows alternate; light to dark brown.

24. *Rib-Grass.* From one-eighth to one-twelfth of an inch in length; oval in shape with one face rounded, the other deeply grooved bearing a central scar; dark brown or amber colored.

25. *Ragweed.* Ranging from one-fifth to one-twelfth of an inch in length; top-shaped; apex pointed, and bearing a crown of four to eight spines; light to brown in color.

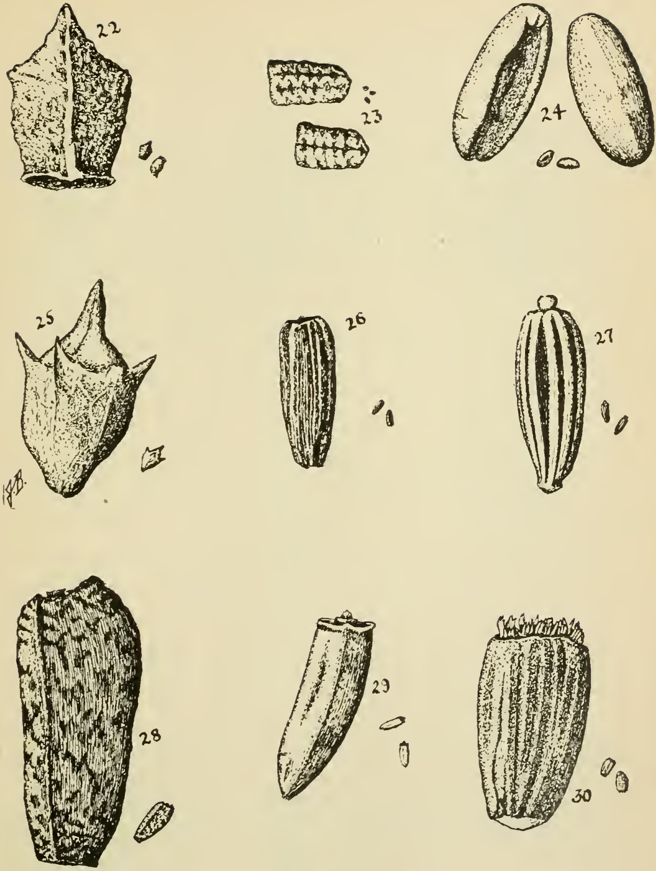
26. *Yarrow.* Seeds about one-twelfth of an inch long; small and thin; slightly egg-shaped; color varying from yellowish-white to gray.

27. *Ox-Eye Daisy.* About one-twelfth of an inch long; ten slender, white ribs running from end to end; a knob at the broad end; and slightly club-shaped.

28. *Burdock.* One-fifth to one-fourth of an inch in length; prismatic and mottled; four or five faces; apex broader than base; apex star in centre of a distinct brown ring.

29. *Canada Thistle.* From one-eighth to one-twelfth of an inch in length; brown in color; somewhat spindle-shaped, but often flattened; top end cup-shaped with a rim and a small central knob.

30. *Chicory.* From one-eighth to one-twelfth of an inch in length; usually light brown; usually cylindrical; top flat and crowned with scales.




The small drawings beside the enlarged drawings represent the natural size of the seeds.

## Descriptions of the Weed-seeds Illustrated on the Opposite Page.

31. *Prickly Lettuce.* Seeds one-eighth to one-sixth of an inch in length; broadly lance-shaped; each face has 5-7 ribs; color dark brown, somewhat mottled with black; apex is tipped with a beak which is almost as long as the seed.

32. *Spiny Sow Thistle.* One-eighth of an inch in length; varying from oval to lance-shaped; flat; each face bearing three narrow ridges which meet at the ends; surfaces smooth; color straw-colored to reddish brown.

33. *Perennial Sow Thistle.* Slightly spindle-shaped with blunt ends and often much flattened; five coarse, finely wrinkled ridges running lengthwise on each face; dark reddish-brown; about one-eighth of an inch long.

34. *Fleabane.* Seeds one-twentieth of an inch long; oval; remnants of pappus bristles remaining often at the apex.

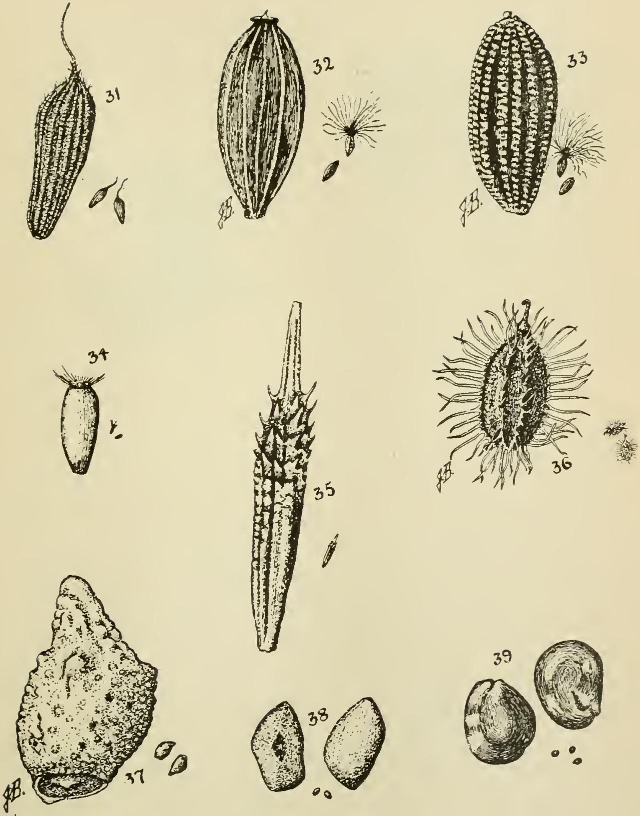
35. *Dandelion.* Seeds one-eighth of an inch long; exclusive of short beak; lance-shaped in outline; ten ridges running lengthwise; provided with barb-like teeth towards the apex; color varies from light to dark brown.

36. *Wild Carrot.* Seeds each one-eighth of inch in length; and flattened on the back; primary ribs slender, bristly, and five in number; secondary ribs, 4 in number. each bearing a row of barbed prickles.

37. *Pigeon Weed.* Nutlets one-twelfth of an inch long; egg-shaped and curved; scar is conspicuous; surface roughened; gray in color.

38. *Broad-Leafed Plantain.* Seeds about one-twentieth inch long; flattened; outline variable from oval to rhomboidal; wavy lines on surface; color, brown.

39. *Pig-Weed.* About one-twenty-fourth of an inch in length; flattened, egg-shaped, or lens-shaped; polished and jet black; a slight notch on sharp edge is the scar; near the scar-notch is a small projecting point.




The small drawings beside the enlarged drawings represent the natural side of the seeds.

A small magnifying glass is very useful in identifying seeds. Perhaps the most convenient glass for the purpose is the *tripod magnifier* (Fig. A), costing about fifty cents. The *linen-tester* (Fig. B) is cheaper, but yet quite serviceable.

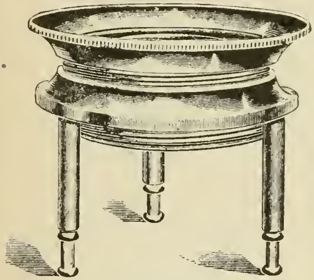


Fig. A. Tripod magnifier.

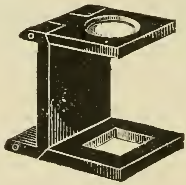


Fig. B. Linen tester.

## Classification of Weeds.

Weeds may be classified according to the length of time they live, as follows:

*Annuals*, or weeds which germinate, bloom, fruit, and die, in one year or season. Corn Cockle is an example.

*Winter Annuals*, which germinate late in summer or autumn, pass the winter as seedlings or immature plants, and complete the cycle of their existence by blooming, fruiting, and dying during the following summer. Such are Chess and Shepherd's Purse.

*Biennials*, which produce leaves and roots the first year, and flowers and seeds the second year, after which they die. The Wild Carrot and Evening Primrose are familiar examples.

*Perennials*, which last from year to year, blooming and seeding annually. These are divided into two classes:

(1) Those with underground creeping stems, such as the Canada Thistle.

(2) Those with roots which do not spread underground, such as Chicory and Plantain.

It is important to know the class to which a weed belongs, as the method of eradicating an annual is often very different from that required to destroy a perennial.

## Eradication of Weeds.

The most important points under this head are:

*First*, a determination to get rid of weeds and to keep the land clean.

*Second*, the method or methods of tillage and cropping.

As regards the latter point, the writer feels that he cannot do better than submit the method outlined by our late Farm Superintendent, Wm. Rennie, whose experience of over thirty years warrants him in speaking with some confidence on the subject. Mr. Rennie's method not only cleans the land but increases its fertility, and those who wish fuller information should consult the college reports for 1895, 1896, and 1897.

For various reasons, very few farms in the older sections of the Province of Ontario are free from weeds, and the question how to clean our lands without incurring too much expense is one of the most important which can engage the attention of Canadian farmers.

In the first place, I would say that all obstructions to cultivation, such as piles of stone, must be removed—hauled away to the woods or an out-of-the-way corner in the winter or some other slack time. Secondly places for harboring weeds, such, for example as snake fences, should be got rid of as soon as possible. On the Ontario Experimental Farm, nearly all field fences have been removed. The outside and lane fences are almost the only ones left. Portable fences are used when required for pasturing live stock.

*Annuals and Biennials.* Wild oats, wild mustard seed, and some other seeds belonging to these classes, have great vitality. If down pretty well beyond the reach of the air, they will live for twenty years, and will germinate as soon as they are brought near the suface.

The best way to destroy annuals and biennials is by thorough and frequent shallow cultivation, early after harvest in stubble ground and in sod plowed for the following year, and at the proper season (spring and summer) among what are called "hoed crops" that is, potatoes, carrots, turnips, mangels, Indian corn, etc. By shallow cultivation the seeds are kept near the surface, and by frequent stirring of the soil they are made to sprout; and having sprouted, they can be killed by further cultivation. Those which sprout late in the fall are destroyed by the winter frost It is impossible to get rid of such weeds by plowing the ordinary depth, say seven or eight inches, once in the fall or at any other time. Plow shallow (not more than four inches in sod and three inches in stubble ground), and harrow and cultivate from frequently, as by each stirring of the soil fresh seed is made to sprout and what has already sprouted is destroyed. When necessary to loosen the soil to a greater depth, use a grubber or a subsoil plow.

*Perennials.* It is necessary to study the habits of perennial weeds to see how they grow and propagate themselves from year to year, in order to keep them in check; and a close examination of almost any of them will show that the buds from which the young plants start are near the surface of the soil. Hence shallow cultivation, similar to that mentioned above, is the effective method of destroying them. Deep plowing only transplants the buds to a greater depth and increases the trouble. Plow shallow (see preceding paragraph), and harrow and cultivate frequently, using a grubber or subsoil plow when it is necessary to stir the soil to a greater depth. As above, the cultivation must be early after harvest and throughout the fall in stubble ground and sod, and in spring and summer among corn, potatoes, and root crops. Ill-timed, irregular or partial cultivation only makes all weeds grow more vigorously.

*Canada thistles, sow thistles, couch-grass, bindweed, etc.*, can be destroyed by the following method · Middle of May gang plow the land about three inches deep and harrow thoroughly. In two weeks, when the weeds are nicely up, cultivate with a common or spring-tooth cultivator provided with wide points that overlap so as to cut off every plant two or three inches below the surface. Then harrow to pull up the plants and leave them die. In the middle of June there will be another crop, and possibly a greater number of plants, but not so vigorous as the first crop. Repeat the operations with the wide point cultivator and the harrow. In July a few delicate plants will make their appearance and will have to be destroyed in the same way. This will be sufficient for most weeds; but bindweed may need one or two extra cuttings with the wide points and a corresponding number of harrowings.

The preceding method will clean the land, but it involves the loss of a year's crop; so it is well to add, that land may be kept comparatively free from weeds without the loss of a crop, by after-harvest cultivation of all fields not in grass, begun with each field *just as soon as the crop is off* and continued throughout the fall, first by shallow gang-plowing and harrowing and afterwards at intervals, as above, by the wide-point cultivator and the harrow. This treatment followed by a hoed crop *properly attended to* will destroy most perennial weeds and all annual and biennial seeds that are near the surface.

*Note.* To Mr. Rennie's method or methods, as above given, I would venture to add one which we have seen carried out with the most satisfactory results by Mr. Rennie on the College farm, and with marked success by farmers in other parts of the Province. It may be put in the imperative form, as follows: Sow much with red clover, in order to have a rich clover sod to plow down for all or nearly all spring crops, taking as far as possible only one crop of hay or pasture before plowing, occasionally two, but not more than two. Plow the clover sod shallow, not more than four inches, early after harvest, say the 1st to the 15th of August, and harrow at once. Let it stand a couple of weeks; then cultivate, the same way as it was plowed, two or three inches deep, with a spring-tooth cultivator. After a while, cross cultivate a little deeper. If possible, cultivate a third, or even a fourth time, going a little deeper each time. Then, if you can manage to do so, rib it up with a double mouldboard plow, as you would for a crop of turnips. When this is done the available plant food (clover roots, etc.) is preserved in the center of the drills, the water runs off early in the spring, and the drills can be levelled with the cultivator and harrow, either for spring grain or for hoed crops.

This method will not only clean land but will greatly enrich it.

## Information from Farmers as to New Weeds, Etc., in Different Parts of the Province.

At the request of the writer, the Ontario Department of Agriculture, in 1898, kindly sent out a few questions about weeds to its regular correspondents, and others, chiefly those who had done satisfactory experimental work in connection with the Experimental Union. A large number of answers were received, and as part of the information contained therein is not given elsewhere in the bulletin, some of the answers are briefly referred to below. The questions were as follows:

1. *What is the character of the soil in your township?* This was to ascertain what species of weeds grow most abundantly in certain kinds of soil.

2. *Are the weeds in your neighborhood more numerous and more troublesome than they were ten years ago?* The majority of the correspondents say that weeds are far more numerous than they were, and that the injury done by them is far greater. The Canada Thistle, however, is spoken of as much less troublesome than it was,—a fact due, no doubt, to the vigorous methods taken to eradicate it from cultivated land, and in a less degree to the law for its destruction on the highways.

3. *Are the provisions of the weed law enforced in your township?* About 95 per cent. answer *No* most emphatically. They say that a number of townships appoint men to look after the Canada Thistle, but that little or nothing is done with other weeds. "The township council takes no action, because the councillors are afraid of losing votes at the next election." "Pathmasters do not enforce the Act, for fear of incurring the enmity of neighbors;" and "rented farms, especially such as belong to loan companies, are often overrun with weeds, to the great injury of neighboring farmers."

4. *What is the estimated annual loss which you sustain from weeds?* Some of the answers to this question are amusing, but the great majority of them show a full appreciation of the fact that a serious loss undoubtedly results from the existence of weeds among farm crops.

Some consider the weeds a blessing in disguise, as they compel lazy and careless farmers to keep on cultivating the soil; and very many, in making their estimate, seem wholly to overlook the loss from the use of plant food and the absorption of soil moisture by weeds. A number estimate their loss at twenty-five cents per acre, and quite a few place it as high as $5 per acre; so, considering the whole list and counting labor, with the loss of soil moisture, fertility, etc., we think that $1.00 per acre is a conservative estimate of the annual loss throughout the Province.

5. *What means do you use to destroy the weeds on your farm? and with what success?* Many full answers were given to this question; and the most valuable information contained in these answers has been set forth under various heads in the descriptions which follow. One point, however, which is strongly emphasized by many, may be mentioned in passing, viz., that no method, however good it may be, is of any use, unless it is faithfully carried out. A lack of thoroughness in the work done for the destruction of weeds always results in failure.

6. *What new weeds have you noticed lately in your locality? Are they spreading rapidly? and how have they been introduced?*

As to *the ways in which the above weeds have been introduced*, the answers are various, but the great majority of the correspondents mention two agencies as chiefly responsible: (1) Impure seed, especially grass and clover seed; (2) Threshing machines.

Several grades of clover seed are sold by seedsmen:—No. 1, or the best quality, is usually clean, but most of it is exported, as Canadian farmers will not pay the price asked for this grade; No. 2, or second quality, is the kind generally sold in country stores throughout the Province. Of the samples referred to on a previous page as having been examined by us, by far the worst were from country stores, for which fact we cannot say that the storekeepers are to blame any more than the farmers who refuse to pay the price necessary to secure the best seed.

We would again urge that every farmer, no matter what the assertions or statements of sellers may be, should examine carefully with a glass all grass and clover seed which he thinks of sowing on his land; and in case he discovers foreign seeds which he does not know, let him send samples to the Ontario Agricultural College, Guelph, and all such samples will be promptly examined and reported upon.

# A NUMBER OF COMMON WEEDS, WITH POPULAR DESCRIPTIONS AND NOTES ON ERADICATION.

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## FIG. 1.

### FOX-TAIL, YELLOW FOX-TAIL, BOTTLE GRASS, OR PIGEON GRASS.

*Chameraphis glauca* (L).

A common weed in stubble, fallow or root fields. It has a perennial root, with stems about two feet high, of erect habit of growth. At the summit of that part of the leaf which sheaths the stem (the ligule) there is a fringe of hairs. The leaves are flat, rough above, and smooth beneath. The dense, close spike, which resembles millet, is bristly and tawny yellow in color.

The seeds are $\frac{1}{8}$ in. long, various shades of brown in color, with transverse wrinkles. They frequently retain their green color, and are quite commonly found as an impurity in clover and grass seed. (See Fig. 1, a.) An average plant produces about 15,000 seeds.

Time of flowering, July-September.

Time of seeding, August October.

*Eradication.* Gangplow stubble ground about three inches deep early in the fall; as soon as the seeds have had time to sprout, cultivate thoroughly; repeat cultivation and rib the land with a double mould board plow the last thing before the frost. Put in a hoed crop (potatoes, roots or corn) next spring and cultivate thoroughly throughout the growing season. Follow with a grain crop seeded with clover, without plowing after the roots, for if the land is plowed it is liable to bring more seed to the surface. When the sod is broken up, plow shallow in the latter part of harvest, cultivate with harrow and cultivator throughout the fall, and rib up as above.

In the early after-harvest cultivation of stubble ground, some harrow the stubble as the first step; and when the weed seeds have sprouted under their light covering, then gang-plow and harrow, and stir afterwards with the cultivator as time permits throughout the fall.

Fig. 1.
Yellow Fox-tail.
*(Chameraphis glauca).*

FIG. 2.

## CHESS, CHEAT OR WHEAT THIEF.

*Bromus secalinus* (L).

A weed naturalized from Europe. It is a winter annual, with fibrous roots and rough coarse leaves. It has large spikelets, dark green in color, of characteristic shape, and grows from three to four feet high.

Many look upon Chess as degenerated wheat, because it appears among fall wheat that has been winter-killed. This idea is erroneous and without foundation. The fact is that Chess will mature seed under adverse conditions, even though the plant be only a few inches high. The seed possesses great vitality, and is often found in wheat and rye.

Chess is most commonly found among wheat and rye.

The flour made from it is dark-colored and has narcotic principles. Care in the selection of seed grain and careful cultivation, tending to prevent the maturing of the seeds, are the chief remedies. The planting of a crop that can be harvested before the Chess matures is a good plan in badly infested localities. An average plant produces about 1,000 seeds.

Time of flowering, June. Time of seeding, July.

" Chess is a typical plant belonging to the genus *Bromus*. Wheat belongs to the genus *Triticum*. Chess will produce Chess and only Chess, and a seed of wheat cannot be sown to produce Chess, and Chess cannot produce wheat under the most favorable conditions of growth.

" In instances where parts of a plant, apparently a combination of Chess and wheat were so united as to seem but one plant, close examination proved them to be parts of separate plants, and that the apparent union was not real."

*Eradication.* Avoid fall sown crops, and follow as far as practicable the same method as is recommended for Mustard. In this case, however, the meadow will require special attention, and any weeds that appear must be removed. If many weeds appear in the meadow, it will be better to break it up and follow the rotation suggested under Fox-tail.

FIG. 2.
CHESS.
(*Bromus secalinus.*)

FIG. 3.

WILD OAT.

*Avena fatua* (L).

An annual weed with erect and smooth stems. The leaves and stems are covered with white bloom, which give a peculiar white-green color to the whole plant. The head forms a loose panicle, with nodding and spreading branchlets. The awn is long and bent, and covered with brown hairs. It is bent most when dry; but if moistened, it uncoils and wriggles around, thus causing the seed to move appreciable distances.

The principal points of differences between the wild and cultivated oats are (1) In the former the chaff is thick and hairy, while in the latter it is thin and hairless; and (2) The wild oat has a long, stiff awn which is bent and twisted when dry, while the cultivated oat either has a much smaller and less stiff awn or none at all. An average plant produces about 800 seeds.

Time of flowering, July. Time of seeding, July-August.

Dispersal— conveyed from place to place by threshing machines, and as an impurity in seed-grain.

Wild oats are at home in any soil that will grow cereals, and they ripen their seeds among almost any cereal crop. The seeds possess wonderful vitality, some of them remaining buried in the soil for years and germinating as soon as they are brought under favourable conditions.

*Eradication.* On a field infested with wild oats, cereal crops should be dropped out of the rotation as far as possible; and hoed crops, soiling crops, hay, and pasture should take their place. To get the land under grass, it should be fallowed during part of the season, the cultivation being frequent and shallow, to destroy all seeds that may have germinated in the upper layer of the soil. The land can then be sown with winter wheat and seeded, or with an early variety of barley, which should be cut on the green side. The treatment mentioned is suitable for pasture land, or land which has produced a hay or soiling crop during the forepart of the season.

Fig. 3.
Wild Oat.
(*Avena fatua.*)

FIG. 4.

## COUCH-GRASS, TWITCH-GRASS, QUACK-GRASS, QUITCH-GRASS, OR QUICK-GRASS; ALSO WHEAT-GRASS.

*Agropyron repens* (L).

Couch-grass is a creeping perennial which grows from 1 to 3 feet high. It has a jointed root-stock which penetrates deeply into the ground and possesses great vitality. The plant produces spikes from 3 to 8 inches long. The small spikelets alternate at each notch of the flower stalk, with the side of the spikelet turned towards the stalk.

The seeds are about ½ in. long, and rather slender (Fig 4, a.). An average plant produces 400 seeds.

Time of flowering, June-July.

Time of seeding, July-August.

Dispersal—the root-stocks are carried around by implements, and the seeds are occasionally found in seed-grain.

Whatever value Couch-grass may have for pasture, its habit of taking and keeping possession of the soil renders it extremely objectionable. It flourishes best in loamy or humus soils, from which it is especially difficult to eradicate.

*Eradication.* As soon as the crop is harvested plow lightly, then harrow with the ordinary harrow, and if necessary cultivate with the spring-tooth cultivator. This shakes the roots free from the soil and makes it possible to gather them up with the horse rake. Burn as soon as they have dried sufficiently. Repeat this process two or three times. If the weather at this time should happen to be dry and hot, so much the better. Late in the fall, rib up the land into drills and allow to stand over winter. The frost in all probably will render material assistance in the eradication. The following spring, plow about the end of May, cultivate well and put in some hoed crop, or summer fallow, sowing buckwheat, the crop to be plowed in. A carefully cultivated crop of rape is recommended as being particularly effective in destroying this pest.

Fig. 4.

*Couch Grass* on right of figure and part of a stalk of *perennial rye-grass* (*Lolium perenne*) on left. Note the arrangement of spikelets in rye-grass.

FIG. 5.

### DOCK, CURLED DOCK, SOUR DOCK, OR YELLOW DOCK.

*Rumex Crispus* (L).

A deep-rooted perennial weed introduced from Europe.

It occurs around buildings, in neglected lanes, along waysides and in pastures. The stem is quite slender, and the leaves are from six to twelve inches long, with wavy margins; hence the common name, "curled dock." The flowers are in racemes, green in color.

The seed is winged, and is carried considerable distances by the wind. The manner of attachment of the seed to the wing is shown in illustration (Fig. 5, a.). The seeds are light brown in color, triangular, with sharp edges and tapering point. They are smooth and shiny (Fig. 5, b).

The wind acts as an agency in scattering the seed, and it is a very common impurity in clover and other seeds used on the farm.

An average plant produces about 17,000 seeds.

Time of flowering and seeding, July-August.

*Eradication.* In most cases this weed can be kept in check by the frequent introduction of well-cared-for hoed crops into the rotation. The shorter the rotation, the better. The later sown hoed crops, especially rape, are more effective than those sown earlier in the season. Before the hoed crop is sown, this weed may be kept from breathing above ground by going frequently over the field with a broad-shared cultivator, which will cut the plants an inch or two below the surface; but as the roots are tough and strong, it may sometimes be necessary to use the gang-plow, or even the single plow. About the 1st of July, the land may be sown with rape in drills, say 26 inches apart, and kept clean, or nearly so, by the horse-hoe and more or less hand hoeing. The rape can be pastured off in the usual way during the fall; and occasionally it may be necessary to put another hoed crop on the same ground the following spring, say a crop of corn; but much depends upon the timeliness, regularity, and thoroughness with which the hoeing is done.


Fig. 5.
Curled Dock.
(*Rumex crispus*)

FIG. 6.

## SORREL, OR SHEEP SORREL.

*Rumex Acetosella* (L).

A perennial with running root-stocks. The stem is slender and erect with branches. The leaves are spear-shaped and quite characteristic. The flowers occur in recemes and are green in color. The foliage has a pronounced acid taste.

The seed is 1-16 in. long, triangular, smooth, and shining when naked, but dull brown when invested by its covering. An average plant produces about 10,000 seeds.

Time of flowering June-September.

Time of seeding, July-October.

Propagation—by its running root-stocks, and as an impurity in clover seed, especially Alsike.

*Eradication.* Sorrel is usually an indication of a poor, sandy, or gravelly soil. It prefers acid soils, hence liming and manuring are effective remedies when the land is well tilled. The remedies given for the Dock (Fig. 5) are applicable to Sorrel, only it requires more frequent use of the broad shared cultivator, which should be used so as to cut the roots just below the surface of the soil, without bringing up any of the creeping root-stocks.

FIG. 6.
SHEEP SORREL.
*(Rumex acetosella.)*

FIG. 7.

## LAMB'S QUARTERS, OR GOOSEFOOT.

*Chenopodium album* (L).

An annual weed widely distributed in cultivated land. It grows to a height of from 2 to 6 feet. The stem is grooved and much branched. The leaves are whitish green below and dark green above. The flowers are inconspicuous and greenish in color.

The seed (Fig. 7, a.) is black and shining, lens-shaped and round, about 1-16 in. in diameter.

Time of flowering, June-October.

Time of seeding, August-October.

Distribution—by seeds, especially as an impurity in clover and grass seeds.

*Eradication.* Late cultivation is especially necessary in combating this weed, as it flowers and seeds till very late in the season. The land should be gang-plowed shallow and harrowed immediately after harvest, and cultivated at intervals until late in the fall, when it may be plowed or ribbed up for a hoed crop the following spring Subsequent treatment the same as for Foxtail (Fig. 1.)

Fig. 7.
Lamb's Quarters.
(*Chenopodium album.*)

Fig 8.

## Pigweed, or Redroot

*Amarantus retroflexus* (L).

An annual, with pink root, stout, erect stem, and many branches. It grows from 1 to 6 feet high. The leaves are light green in color, and ovate in shape. The flowers are in spikes, which terminate branches, or are from the axils of the leaves, and are green in color.

The seeds (Fig. 8, a) are round and lens-shaped, smooth and shiny black in color, resembling the seed of Lamb's Quarters, but slightly smaller and thinner. An average plant produces 15,000 seeds.

Time of flowering, July-September.

Time of seeding, August-October.

Dispersal—the seed is distributed by the wind and as an impurity in grass seed.

*Eradication.* Special attention must be given to fall cultivation of the soil, so as to prevent plants from ripening, and to sprout and destroy the seeds which have fallen upon the ground. The land should be gang-plowed shallow and harrowed immediately after harvest, and cultivated at intervals until late in the fall, when it may be plowed or ribbed up for a hoed crop the following spring. Subsequent treatment the same as for Foxtail (Fig. 1).

Fig. 8.
Pig-weed.
(*Amarantus retroflexus.*)

FIG. 9.

## PURSLANE, OR PURSLEY.

*Portulaca oleracea* (L).

Purslane is pre-eminently a garden weed and is readily recognized by its fleshy leaves and stem, which lie prostrate on the ground. It is an annual.

The stems are red, and the leaves wedge-shaped and clustered at the ends of branches. The flowers are bright yellow, about ¼ in. across and open only during full sunlight for a few hours in the morning. The seeds (Fig. 9, a), in small capsules, are black, kidney-shaped, and extremely small. An average plant produces 60,000 seeds

Time of flowering, July, until frost.

Time of seeding, August, until frost.

Dispersal—by seeds.

Purslane has been used as hog feed in very dry seasons, but the cost of gathering it is too great.

*Eradication.* Careful hoeing and constant cultivation. The latter should be as early as possible. The same treatment should be followed as that outlined for Foxtail (Fig. 1).

Fig. 9.
Purslane.
*(Portulaca oleracea.)*

Fig. 10.

Corn Cockle, or Corn Campion.

*Agrostemma githago* (L).

An annual adventive from Europe, about 1 to 3 feet high, with erect habit of growth. It has but few branches, and the stems are all very hairy, with whitish-green hairs. The leaves are rather long and narrow, with pointed ends. The flowers are red to purple, and the flower cup (calyx) has long lobes, three or four times the length of the petals.

The seed capsules are generally well filled with seed which is black in color and kidney-shaped, with tubercles (small conical projections) arranged in rows around the sides of the seed. (See Fig. 10, a.) The seed is about ⅛ in. across. An average plant produces about 500 seeds.

Time of flowering, July.

Time of seeding, August.

Dispersal—by birds, in manure, and as an impurity in seed again.

It may be noted, in passing, that the seed is injurious to young chickens, and the husks of the seed often elude the miller and appear as black specks in flour, which is seriously damaged thereby. An old writer, Gerarde, says :

" What hurt it doth among corn (wheat) the spoyle unto bread, as well in colour, taste, and unwholesomeness, is better known than desired."

*Eradication.* Sow clean seed ; and when the weed is not very thick pull it by hand. Otherwise use the same treatment as for mustard. (See Fig. 15).

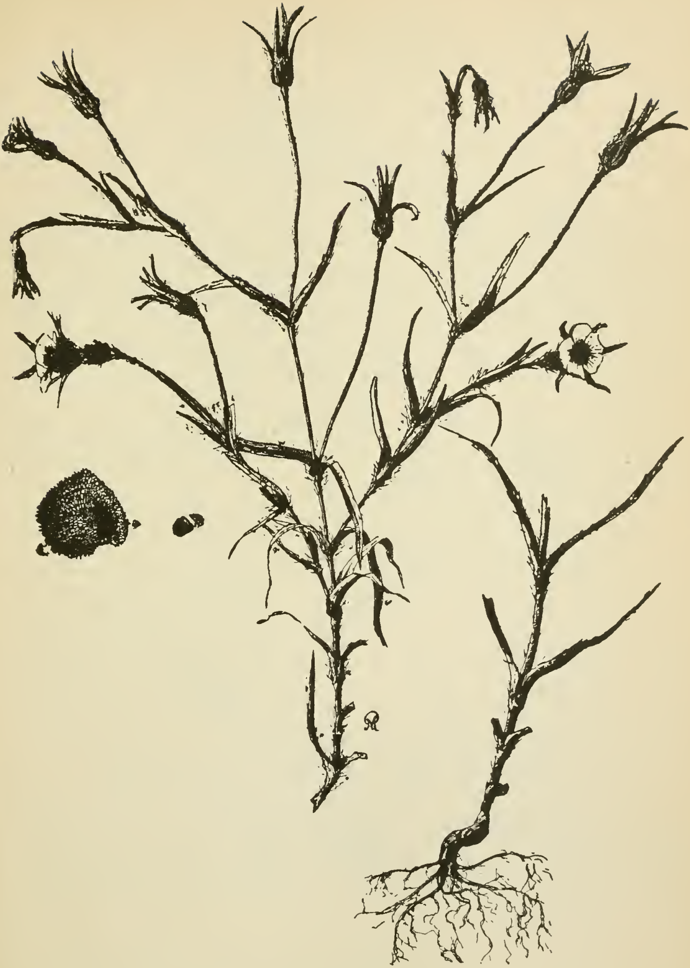

Fig. 10.

Corn Cockle.

*Agrostemma githago.*

Fig. 11.

### Bladder Campion, or Cow Bell.

*Silene inflata* (L).

A naturalized perennial which promises to be a bad weed in Ontario; and it is spreading very fast. It grows from 6 inches to 2 feet in height, and branches from the base. The leaves are oblong and vary greatly in size. The flowers are white, about ½ in. broad, and are arranged in a loose panicle. The flower cup (calyx), veined and inflated like a bladder, distinguishes the plant from others that resemble it.

The seeds are brown and kidney-shaped, with minute tubercles disposed regularly over the surface (Fig. 11 a). An average plant produces about 9,000 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—by root-stocks and as an impurity in seeds.

The Night-flowering Catchfly (*Silene Noctiflora*), resembles the Bladder Campion; but it is an annual, tall and very leafy, with a viscid secretion all over its stem, often so profuse that the stems and leaves are covered with small insects entangled in it. It opens at night and possesses a fragrant smell. It is not so bad a weed as its relative, the Bladder Campion. In Fig. 11 are shown the seeds of these two plants, natural size and enlarged. That on the left is Bladder Campion, that on the right is the Night-flowering Catchfly.

*Eradication.* For these weeds practically the same treatment as outlined for the creeping perennials (Canada Thistle, etc.) will answer, although the plow may have to be resorted to more frequently, instead of the broad-shared cultivator, on account of the size and thickness of the roots.

Fig. 11.
Bladder Campion.
(*Silene inflata.*)

### Fig. 12.

## White Campion, or White Cockle.

*Lychnis alba* (L).

A biennial weed introduced from Europe, with hairy and branching stems from 1 to 3 feet high. Like the Night-flowering Catchfly it has a viscid secretion, which attracts many insects. The leaves are oblong, with acute tips. The flowers are in loose panicles, white or pink in color, and nearly ¾ in. broad. As a rule they open at night and remain so until the morning of the following day. The pod has short teeth around the top, which curl back when dry, and the seeds are distributed by the winds swaying the stem, when the seeds drop out. In wet weather these teeth straighten out and completely close the opening at the top.

The seed (Fig. 12, a) is brown in color and kidney-shaped, with tubercles regularly disposed over the surface. An average plant produces 10,000 seeds.

Time of flowering, June-August.

Time of seeding, July-August.

Dispersal—by wind and as an impurity in seeds.

*Eradication.* Exercise great care in cleaning seed grain, and examine all purchased grain with a sharp lookout for this seed. If the weed be on the farm, follow the method outlined for Foxtail (Fig. 1) or Mustard (Fig. 15).

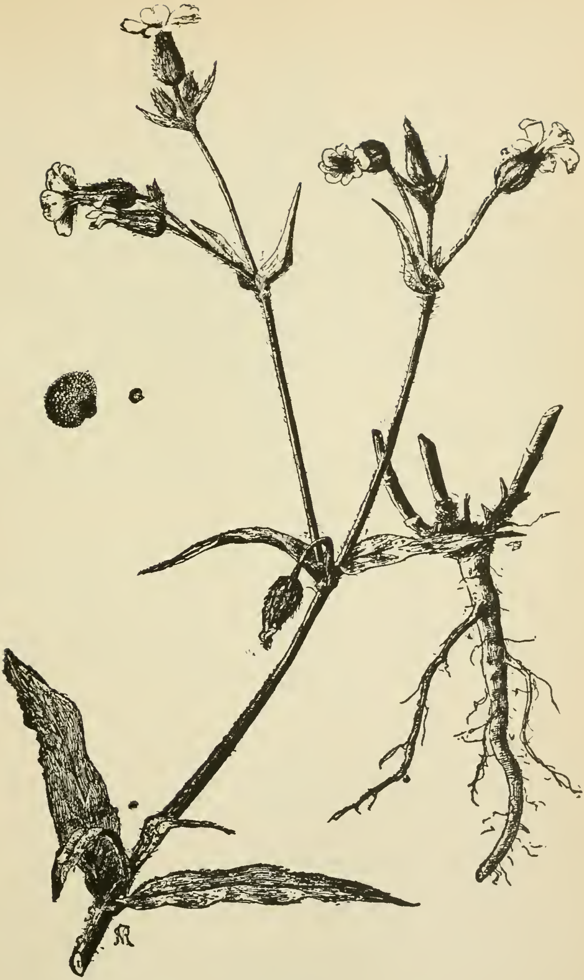

Fig. 12.
White Cockle.
(*Lychnis alba.*)

Fig. 13.

## Pepper Grass, or Tongue Grass.

*Lepidium Virginicum* (L).

A native annual which grows from six inches to a foot and a half high. The stem usually has many branches, and the lower leaves terminate in a large lobe (with small lateral ones), with edges slightly cut in along the margin. The upper leaves are tapering. The flowers are small and white, with slender spreading flower stalks. The seed pods are round, with a very small wing at the top and a notch at the extremity. The end of a branch with seed pods is shown nearly natural size in Fig. 13, a.

The seeds (Fig. 13, b) are reddish brown, flat and oval in shape, and 1-16 in. long. The average plant produces about 18,000 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—by birds and as an impurity in clover seed.

Eradication. Be careful to prevent the plants from seeding, and do not plow them under when half ripe, as many of the seeds will germinate even though partially matured. Pull and burn where only a few plants exist, and when they are numerous use the method employed for the eradication of Mustard (Fig. 15).

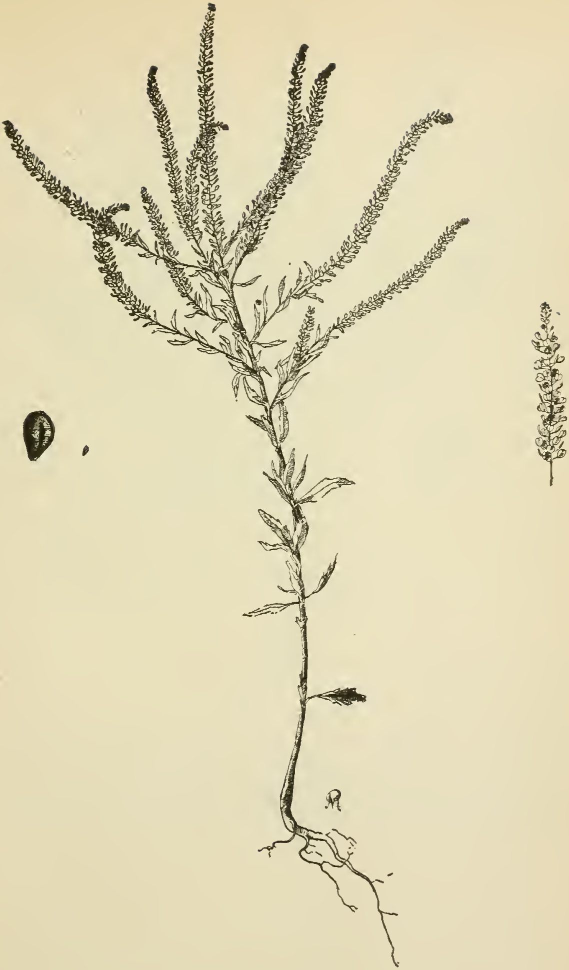

Fig. 13.
Pepper Grass.
(*Lepidium Virginicum.*)

### Fig. 14.

### Penny-cress, Bastard-cress, French Weed, Wild Garlic, or Stink-Weed.

*Thlaspi arvense*, (L).

A winter annual, introduced from Europe, and a very bad weed. It is very abundant in Manitoba and is becoming rather common in Ontario. It grows as an erect plant, with a number of branches from the upper part. The leaves are numerous during the first of the season, and clasp the stem by ear-line lobes. The flowers are white and small, with spreading flower stalks. The pods which succeed the flower are very characteristic. They are nearly orbicular, about half an inch broad, quite flat, with a broad wing all around, and notched at the top. Fig. 14 shows this peculiarity. Each pod produces about twelve seeds, which are dark brown to black and oval in shape, with curved lines. An average plant produces about 20,000 seeds.

The plant has a peculiar odour, resembling that of garlic, hence some of the common names. The seed also has a very pungent taste. When eaten by milch cows, it imparts a disagreeable flavor to the milk.

Time of flowering, May-September.

Time of seeding, June-September.

Dispersal—chiefly by the wind.

*Eradication.* Continuous growing of hoed crops with thorough cultivation thereof, followed by heavy seeding with rye. In places where the weed is very thick, mowing and burning is a good remedy. The method outlined for eradicating Mustard is applicable to this weed. (Fig. 15).

Fig. 14.
Penny-Cress.
(*Thlaspi arvense*.

FIG. 15.

WILD MUSTARD, CHARLOCK, OR HERRICK.

*Brassica sinapistrum*, (L).

Among the worst weeds in Ontario is the Wild Mustard, an annual, naturalised from Europe, with fibrous roots and erect habit of growth. The stem is rough, with stiff hairs somewhat scattered over the surface. The branches arise from the upper part of the stem and bear oblong leaves; and the lower leaves have one terminal large lobe and several smaller lateral ones (lyre shaped). The flowers are yellow, showy, and about $\frac{2}{3}$ in. broad, with stout flower stalks, which are more noticeable when the plant is in fruit. The pods, which appear on the lower part of the stem whilst the top is still in flower, are from 1 to 2 inches long, and are either spreading or ascending.

The shape of the pod is characteristic; it is constricted between the seeds, thus giving the appearance of a rounded enlargement where each seed is borne. This appearance is termed "knotted." The pod terminates in a two edged beak, and the two valves of the pod are strongly veined or ribbed.

The seed (See Fig. 15) is black, $\frac{1}{8}$ in. in diameter, perfectly spherical, and very much like rape or turnip seed; and it retains its vitality for a long time when buried in the soil. An average plant produces 15,000 seeds.

Time of flowering, June-September.

Time of seeding, July-September.

Dispersal—by birds and implements, but chiefly as an impurity in seed.

*Eradication*. Owing to the great vitality of the seed, Mustard is a very hard weed to eradicate. The seeds, once in the ground, live for years and continue to germinate as they are brought near the surface. Hence it takes patience, a great deal of labor, and a long time to get rid of the weed, when it once gets possession of the land. When present only in small amounts, hand-pulling is the best method, provided the pulling is done before seeds have formed; and as persons pulling in a hurry cannot wait to examine for seed, it is best to put the weeds, as they are pulled, in bundles where they can be burned when dry.

When fields are overrun with the weed, it is best to proceed as follows: Harrow stubble-ground early after harvest, or gang-plow and harrow. As soon as the seeds have had time to sprout, cultivate thoroughly; repeat cultivation at intervals; and rib up with a double mould-board plow the last thing in the fall. Put in a hoed crop, either roots or corn, the following spring, and cultivate it thoroughly throughout the growing season. Cultivate and harrow well two or three times after roots or corn, having first run the plow along each row of corn roots to cut the roots and turn them up; and rib up before the frost. (If the plow is used after roots or corn, it is likely to bring

FIG. 15.
MUSTARD.
(*Brassica sinapistrum.*)

more seed to the surface). Sow a crop of grain the following spring and seed with clover. Pull weeds by hand out of the grain crop ; take a crop or two of hay, or pasture ; and break up the clover sod, treating it as outlined in the note to Mr. Rennie's method of cleaning land. (See page 15). When necessary at any stage in this method, use a grubber or subsoil plow to stir the soil to a greater depth than is reached by the surface cultivation.

*Blue stone method.* When mustard plants are sprayed with a 2 per cent. solution of blue stone (blue vitriol, or copper sulphate), which is made by dissolving one pound in 5 gallons of water, or 9 pounds in 45 gallons of water, they are killed. It is necessary that the plants be sprayed early, just when coming into bloom, and on a fine bright day, if the best results are to be obtained. A barrel (45 gallons) should spray an acre.

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FIG. 16.

WORMSEED MUSTARD, OR TREACLE MUSTARD.
*Erysimum cheiranthoides*, (L.)

A native weed, which seems to be spreading rapidly through the Province. Many specimens have been sent here for examination during the past year.

An annual or winter annual with erect and branching stems from 8 in. to 2 ft. high. The foliage is bright green and abundant. The leaves are long, tapering at the base into a short petiole, and they are covered with T-shaped hairs. The flowers are yellow and about $\frac{1}{4}$ in. across. The little stalks (pedicels) holding the pods, come out from the stem obliquely, but the pod stands erect on the pedicel, parallel with the stem. The pod is about an inch long and four-angled, with one row of seeds in each cell. The seeds are 1-16 in. long and light brown in color, with a furrow on one side (Fig. 16a). An average plant produces 25,000 seeds.

Seeds give a bitter taste to feed containing them.

Time of flowering June-July. Time of seeding, July-August.

Dispersal—frequently as an impurity in Clover seed.

*Eradication.* Hand-pulling and burning is the best remedy when the weed occurs in small quantities; but where there is much of it, the following procedure is advised : Harrow stubble-ground early after harvest, or gang-plow and harrow. As soon as the seeds have had time to sprout, cultivate ; repeat the cultivation, and rib up the land with a double mouldboard plow the last thing in the fall. Put in a hoed crop, either roots or corn, the following spring, and cultivate thoroughly throughout the growing season. Cultivate after the roots or corn, sow a crop of grain, and seed with clover. If not too much, pull weeds by hand out of the grain crop ; take a crop or two of hay or pasture ; and break up the clover sod, treating it as outlined in note to Mr. Rennie's method of cleaning land. (See page 15.)

Fig 16.
Wormseed Mustard.
(*Erysimum chieranthoides*

Fig. 17.

## Shepherd's Purse.

*Capsella bursa-pastoris*, (L).

A winter annual, naturalised from Europe, with a long, deep, tap root. The root leaves are lobed and form a large rosette which lies close to the ground, and in this state it passes the winter. The following spring a more or less branched stem arises, with arrow-shaped leaves thereon. The flowers are very small and white in color, and are much less conspicuous than the seed vessels, which are triangular in shape, and are attached to the stalk or pedicel at the lower apex of the triangle. From the character of these pods, the plant obtains its scientific and common name. The triangular pod is divided down the centre by a partition, forming two cells, each of which contains from 10 to 12 seeds, (Fig. 17, a). In size the plant varies greatly from a few inches to two feet, depending on the soil and locality. But even a very diminutive plant produces many seeds. The seed is very small, light brown in color, and oblong in shape, (Fig. 17). An average plant produces over 50,000 seeds. Fig. 17 shows shape of seed, also the arrangement of seeds in the pod.

Time of flowering, early spring till the beginning of winter.

Time of seeding, early spring till the beginning of winter.

Dispersal—as an impurity in grass seed; also by birds, as the pods when ripe open and drop the seeds, which are eaten by birds, and often evacuated without digestion or injury.

*Eradication.* It easily succumbs to cultivation; and as the plant spreads only by seed, persistent effort should be made to prevent seeding. The method employed against the preceding weed may be used for eradicating the Shepherd's Purse. (Fig. 16).

Fig. 17.
Shepherd's Purse.
(*Capsella bursa-pastoris.*)

Fig. 18.

### False Flax, or Gold of Pleasure.

*Camelina sativa* (L).

This weed probably came to this country in imported flax seed. In Europe it is cultivated for the fine oil extracted from the seed, which is used in feeding cattle. Its common name arose from its supposed resemblance to flax.

An annual and winter annual, with simple or branching stems; the lower leaves are long, with a stem, or petiole; and the upper ones clasp the stem with arrow-shaped bases. The flowers are numerous, yellow, and somewhat inconspicuous. The seed vessel, or pod, is pear-shaped or globular, with a small projection from the upper end. The little stalks holding the pods are slender and spreading or ascending. The seed is brown and somewhat larger than that of Shepherd's Purse. (Fig. 18). An average plant produces about 40,000 seeds.

Time of flowering, June-August.

Time of seeding, July-August.

Dispersal—as an impurity in flax and clover seed, and occasionally in grain.

*Eradication.* Plow lightly as soon as the crop is harvested. Harrow and then cultivate frequently throughout the autumn, to destroy the young seedlings. It is important that this autumn cultivation should be thorough. Grow a hoed crop the following year. The rotation of crops should be modified in the infested fields by dropping winter wheat out for a time. Grass seed should be sown along with the spring wheat or barley.

FIG. 18.
FALSE FLAX.
(*Camelina sativa.*)

Fig 19.

## Wild Carrot, Bird's Nest, or Devil's Plague.

*Daucus carota* (L.)

This is a biennial, naturalized from Europe, with a deep, strong tap root, a bristly stem, and much divided leaves like the cultivated carrot. The clusters of flowers are in compound umbels which resemble bird-nest cavities.

Time of flowering, July-September.

Time of seeding, August-December.

Dispersal—by seeds carried by wind and animals.

*Eradication.* Spudding is quite effective when the roots are cut before blossoming the first season. When the field becomes badly infested it should be plowed and cultivated and treated to a hoed crop, as described for the treatment of Blue weed (page 64).

Fig. 19.
Wild Carrot.
(*Daucus Carota.* L.)

FIG. 20.

BINDWEED,

*Convolvulus arvensis* (L).

A very troublesome weed which winds its tough and curling stems around the stalks of various plants, partially chokes them, and thereby hinders their growth. It is a perennial with a very extensive creeping root which penetrates far into the soil, and any piece of the root possessing one or more buds is capable of starting new plants, hence it is necessary to clean implements very thoroughly after they have been used in a field containing this weed. The stems are branched and either trail on the ground or climb by twisting around some other plant. The leaves are rather small, with 2-4 lobes at the base, giving them an arrow-headed shape. The flowers are white or rose-colored and 1 inch across. The seeds, three in number, are large, black, and angular, and are held in a spherical capsule (Fig. 20). An average plant produces about 160 seeds.

Time of flowering, June-September. Time of seeding, August-October.

Dispersal—chiefly by means of its creeping roots ; sometimes as an impurity in seed grain.

*Eradication.* This is a very difficult weed to eradicate, and careless cultivation only increases the trouble by carrying the roots from place to place. Salting is recommended by some practical farmers who have succeeded in eradicating this very troublesome pest ; but we cannot speak from experience as to the value of this method of treatment.

The weed may be kept in check by the frequent introduction of well cared-for hoed crops into the rotation, and the shorter the rotation the better. The later sown hoed crops, especially rape, are more effectual than those sown earlier in the season. Before the hoed crop is sown, the weed may be kept in check by going frequently over the field with a broad-share cultivator, so as to cut all the plants an inch or two below the surface without bringing up any of the creeping root-stocks. About the 1st July the land may be sown with rape in drills, say 26 inches apart, and during the early growth of the crop the weeds may be kept in check by means of the horse-hoe, with more or less hand-hoeing. If the land has been well manured or is naturally rich in vegetable matter, the rape will make a rank growth and smother some of the weeds. The rape may be pastured in the fall, and in extreme cases may be followed by another hoed crop, such as corn. If the corn is well cultivated and hoed, most, perhaps all, of the plants will be destroyed.

In some cases it may be advisable to summer-fallow, and in such cases it is best not to plow more than is absolutely necessary, but to

Fig. 20.
Bindweed.
(*Convolvulus arvensis.*)

depend mainly on the broad-share cultivator. Buckwheat sown on summer-fallow and plowed under when coming into blossom, followed by surface cultivation with broad-share cultivator, will assist very much in killing the weed. If necessary, the summer-fallow may be followed by a hoed crop.

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Fig. 21.

## Dodder, Clover Dodder, Devil's Gut, or Strangle Weed.

*Cuscuta epithymum* (Murr).

Judging from the number of enquiries made about Dodder, we fear that it is spreading rapidly in the Province of Ontario.

The seed takes root in the soil and puts forth a shoot which winds around some living plant. Having a good start, the shoot disconnects itself from the earth and derives its nourishment from the juices of the plant to which it clings. Drummond says:—"There are certain plants—the Dodder for instance—which begin life with the best intentions, strike true roots into the soil, and really appear as if they meant to be independent for life. But after supporting themselves for a brief period, they fix curious sucking discs into the stem (Fig. 21, (3) ) and branches of adjacent plants, and, after a little experimenting, finally cease to do anything for their own support, thenceforth drawing all their supplies ready made from the sap of their host. In this parasitic state the Dodder has no need for organs of nutrition of its own, and Nature therefore takes them away. Henceforth, to the botanist, it presents the degraded spectacle of a plant without a root, without a twig, without a leaf, and having a stem so useless as to be inadequate to bear its own weight."

The stems are very slender and red in color, curling around clover or grass and completely choking it, as well as appropriating its juices. It puts forth dense clusters of small whitish flowers, which are succeeded by rounded pods full of seeds. The seeds are small, grey or yellowish-brown, and round in shape. An average plant produces about 2,500 seeds. There are numerous species of dodder, parasitic on flax, onions, and a variety of other herbs and small shrubs.

Time of flowering, June-July.

Time of seeding, July-September.

Dispersal—often as an impurity in clover and lucerne seed.

*Eradication.* Guard carefully against it in clover and other seeds. Cut before ripening, as near the ground as possible, collect, and burn; and modify the rotation so as to leave clover out for a time.

Fig. 21 [1]. Dodder on Grass and Clover.

Fig. 21 [4].
Dodder Seed.
Natural size and enlarged five times.

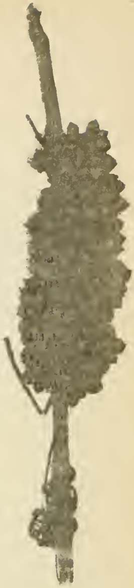


Fig. 21. [5]. Dodder.
Showing the seeds in situ.

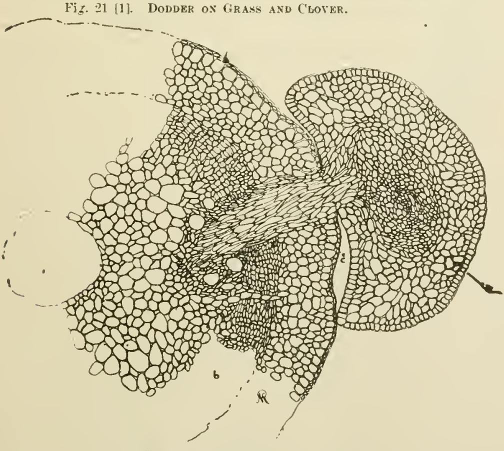


Fig. 21 [3]. Dodder.
(*a*) Cross-section of Dodder stem.
(*b*) Cross-section of Clover stem.
(*c*) Sucker from stem of Dodder.

Fig. 21 [2]. Dodder growing on stem of Hop.
(*After Kerner.*)

FIG 22.

## HOUND'S TONGUE, DOG BUR, OR BURS.

*Cynoglossum officinale*, (*L.*)

A biennial weed, with erect hairy stem, of rank growth, and much branched, one to three feet high. The lower leaves have petioles; the upper ones clasp the stem. They are 6-12 inches long and covered with downy hair, and have a disagreeable odour resembling that of mice. The flowers are small and lurid purple-red in color. The fruit consists of a broad, rounded bur, $\frac{1}{4}$-inch long, with one flat side and covered with short spines which enable it to adhere to clothing or to animals (Fig. 22a). An average plant produces about 600 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—chiefly by animals carrying the burs.

*Eradication.* Spud or cut deep in fall and early spring; the former to destroy the plant in its first year, and the latter to complete the destruction by removing those that escape the first cutting.

Fig. 22.
Hound's Tongue.
*(Cynoglossum officinale.)*

## Fig. 23.

### Blue Weed, Viper's Bugloss, Blue Thistle, or Blue Devil.

*Echium vulgare*, (L).

A biennial weed naturalized from Europe, with deep tap root, which penetrates to a great depth. During the first year, the portion above ground is a rosette of leaves; and from the centre of this, next season, bristly, hairy, and erect stems arise one to two and a half feet high. The leaves are oblong, two to six inches in length, with both upper and lower surface hairy. The flowers are numerous, arranged in a rich spire, and are azure blue in color. The seeds are hard and brown in color, with a broad base and angular body $\frac{1}{8}$ in. long (Fig. 23a). An average plant produces 3,500 seeds. The seeds are probably dispersed in winter by the wind, as they remain for a long time the plant.

Its names, both Latin and English, are significant of the notion that it was an effectual remedy against the bite of a viper.

The weed prefers gravelly and lime soils.

Time of flowering, July-October.

Time of seeding, August-October.

Dispersal—by seeds, especially in winter when they are blown over the snow.

*Eradication.* This weed gives very little trouble in arable land, if the cultivation is at all thorough. In fence corners, on roadsides, and in waste places, cutting below the crown with a spud, is practically the only effective method of destroying the weed. Sometimes, however, this is impracticable, because of the number; and in such cases, some special treatment, similar to that recommended for the Dock (Fig. 5) may be resorted to.

FIG 23.
BLUE WEED.
(*Echium Vulgare.*)

Fig. 24.

## Mullein, or Velvet Dock.

*Verbascum thapsus, (L).*

The mullein is a weed introduced from Europe,—very common in waste places, road sides, and gravelly or sandy pastures. It is a biennal, with large, long roots, from which spring a tall and usually unbranched stem, 2 to 6 feet high. Both stem and leaves are densely woolly all over, with branched hairs. The leaves are whitish, thick, and velvety to the touch. The flowers are yellow and arranged on densely crowded elongated spikes. The capsule containing the seeds is about $\frac{3}{8}$ in. long, and the seeds are small, about 1-20 in. long, six-sided, with irregular ridges running lengthwise between the sides. The color of the seed is dark brown. An average plant produces 6,000 seeds.

Time of flowering, July-September.

Time of seeding, August-November.

Dispersal—as an impurity in clover and grass seed.

*Eradication.* Spud or cut below the crown; or dig up the roots when young; or break up the sod and grow hoed crops. It easily succumbs to cultivation.

The Moth Mullein (*Verbascum blattaria*), is a worse weed than the common mullein, as it infests meadows and bears far more seed. The seed is often found as an impurity in clover and timothy. The plant itself is smooth and slender, from 2-6 feet high, with dentate leaves. The flower is yellow, with brown marks on the back of the petals; and the stamens have violet filaments. The seed is brown, very small, and six-sided. Treat it the same as common mullein.

In Fig. 24 are shown the seeds of the mulleins—the upper seed is the common mullein, the lower is the moth mullein.

Fig. 24.
Mullein.
(*Verbascum Thapsus*).

FIG. 25.

## PLANTAIN, BLACK PLANTAIN, RIB-GRASS, OR RIB-WORT.

*Plantago lanceolata, (L.)*

This plant was once very generally believed to be a favorite food of cattle, yet the opinion of most agriculturists is against it. It is considered a bad weed, especially when it appears in lawns. Numerous inquirers ask what it is, and how to get rid of it. It is a perennial or biennial, with a short thick root-stock, of erect growth, or more generally, lying on the ground as a rosette of leaves. At the base of the leaves there are tufts of brown hair; and the leaves themselves are long, narrow and tapering, with prominent veins, or ribs running lengthwise; hence some of the popular names. The flower-stock is slender and channelled, is without leaves and terminates in a dense spike. The stamens project from the inconspicuous flowers, giving a whitish appearance to the whole head. The seeds are enclosed in small pods, each containing two seeds. The seeds are about 1-12 of an inch long, brown and shiny, with a grove on one side, in the centre of which there is a black spot. The opposite side is rounded, as are also the ends (Fig. 25, a). An average plant produces 1,200 seeds.

Time of flowering, June-September.

Time of seeding, July-September.

Closely allied to this plant is the Broad Leafed Plantain (*Plantago major*), which has broad oval leaves and very long tapering spikes.

The seeds of both of these weeds are very common in clover and grass seed; and persons buying these seeds or lawn mixtures, should examine closely and guard carefully against plantain seed.

*Eradication*. If the plants are not numerous, cut below the crown with a spud. If they are, use treatment outlined for Mustard (Fig. 15).

Fig. 25.
Plantain.
*(Plantago lanceolata.)*

FIG. 26.

RAGWEED, HOGWEED, BITTERWEED, OR ROMAN WORMWEED.

*Ambrosia artemisiæfolia*, (L).

Ragweed is an annual. The stem is much branched and slightly hairy, from 1 to 3 feet high. The leaves are very finely divided, the lower surface being of a lighter color than the upper. The flower heads are very numerous, from 1 to 6 inches long, green, and inconspicious. The flowers are yellow, 1-6 inch across, infertile in the terminal spikes, and fertile only at the base of the spikes. The seed is dark brown, with a sharp tip, around which are arranged 4 to 6 spines, 3-16 inches long. They have great vitality and remain in the soil a long time without injury. An average plant produces about 5,000 seeds. The seed has a bad taste and gives a peculiar odour to the milk of cows which eat it.

Time of flowering, July-September.

Time of seeding, August-November.

Dispersal—as an impurity in seed grain; and by wind and water, being borne long distances by freshets.

*Eradication.* For the eradication of this weed, special attention must be given to the fall cultivation of the soil, to prevent seeds from ripening. Gang-plow or cultivate, and harrow stubble ground immediately after harvest, and repeat cultivation at intervals until late in the fall; then plow or rib up, and follow with a hoed crop. Care should be taken with the hoed crops that no specimens of Ragweed go to seed. When in grass, go over with a mower in September or October, if any plants are likely to mature seed. Do not sow late maturing crops. Ragweed when eaten by cows causes *bitterness* in milk.

Fig. 26.
Rag Weed.
(*Ambrosia artemisiefolia.*)

FIG. 27.

## YELLOW DAISY, CONE-FLOWER, BLACK-EYED SUSAN, OR NIGGERHEAD.

*Rudbeckia hirta*, (L).

A biennial and sometimes annual weed found in pastures and meadows. It grows about 1 to 3 feet high. The stems are sparingly branched and very bristly. The leaves are thick, hairy, oblong and tapering towards the point. The flower is about 1 in. across, with orange yellow rays or petals (10 to 20 in number) and dark purple brown discs almost spherical or cone-shaped. The seeds are dark brown, almost black, four angled, and about $\frac{1}{8}$ in. long, with no pappus, or tuft of hair (Fig. 27, a). An average plant produces about 2,000 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—as an impurity in seed grain.

*Eradication.* It can generally be killed by mowing, but it is sometimes necessary to break up meadow or pasture land, as suggested in note to Mr. Rennie's method of cleaning land (see page 16), and follow with a hoed crop. If this is well cared for, it will destroy all Cone-flowers.

Fig. 27.
Cone Flower.
(*Rudbeckia hirta.*)

Fig. 28.

## Oxeye Daisy, White Daisy, White Weed, or Poverty Weed.

*Chrysanthemum leucanthemum*, (L).

The Oxeye Daisy is a weed naturalized from Europe, and is very closely related to the Chrysanthemum or national flower of Japan.

It is a perennial with short, thick rootstocks, possessed of much vitality. Very many stems spring from one root. It grows from 6 inches to 3 feet high. The leaves slightly clasp the stem, the lower ones, narrow, long, and toothed along the edges, the upper ones, small and without teeth. They are slightly aromatic, more perceptibly so if bruised. The flowers are 1 to 2 inches broad, on long stalks, with from 20 to 30 white rays and bright yellow disc. The seed is about 1-12 in. long and angled, with alternate white and black longtitudinal ribs. It has a short point but no pappus (Fig. 28). An average plant produces 7,500 seeds.

Time of flowering, June-August.

Time of seeding, June-September.

Dispersal—chiefly in grass seeds and by birds.

*Eradication.* The Daisy is most troublesome in pastures, and can be got rid of only by breaking up the sod. It can be eradicated by the method outlined for Canada Thistle (Fig. 30); or by seeding down to clover and plow up after one crop has been cut and taken off. The clover should always be cut before the Oxeye Daisy has had a chance to mature seed.

FIG. 28.
OXEYE DAISY.
(*Chrysanthemum leucanthemum.*)

FIG. 29.

## BURDOCK, GREAT BUR, CLOT-BUR, OR BEGGAR'S BUTTON.

*Arctium lappa* (L).

A biennial weed with tremendous roots, probably the largest of all weed roots. This root is uniform in size for a foot below the surface; further down it is much branched and has a great hold on the ground. The stem is much branched (from 4 to 9 feet high) and rough, with broad rounded leaves, the lower surface of a lighter green than the upper. The flower heads occur in clusters and are purple in color. The flower receptacle, or involucre, as it is called, is composed of hooked spines, which are very adhesive and do much injury to the wool of sheep. The seeds are brown, $\frac{3}{8}$ in. long and spotted with darker brown (Fig. 29).

Time of flowering, July-September.

Time of seeding, August-October.

Dispersal—chiefly by animals carrying the seed from place to place.

The plant when burnt yields a good quality of alkaline ash, equal to the best potash; and a decoction from the roots is said to be equal to the juice of Sarsaparilla as a blood purifier, etc.

*Eradication.* Cut below the crown with a spud and burn the tops.

FIG. 29.
BURDOCK.
(*Arctium lappa.*)

Fig. 30.

Canada Thistle, or Creeping Thistle.

*Carduus arvensis*, (L. & Robs).

This weed was originally introduced from Europe, and hence incorrectly named Canada Thistle. It is a hardy perennial, with numerous underground stems which bear a large number of shoots. (See Fig. 29, illustrating two of these shoots). It grows to a height of 1 to 3 feet. The leaves are narrow and long, deeply indented into very prickly, lobed segments. The leaf has a crimped appearance, and at the base slightly clasps the stem. The under surface of the leaf is woolly, the upper surface less so. It produces numerous heads containing flowers, which are ½ to ¾ inches across and of a lilac-purple color. The flower is smaller than that of other thistles. The seed is grey, oblong, and about 1-8 in. long, with slight longitudinal markings. Attached to the top is a conspicuous tuft of long hairs (the pappus) (Fig. 30, a). The seed is carried long distances by the wind. An average plant produces 3,500 seeds.

Time of flowering, June-August.

Time of seeding, July-September.

Dispersal—chiefly by the wind.

Great care should be taken to prevent Canada Thistle from seeding.

*Eradication.* The Canada Thistle can be eradicated in several ways, if thorough work is done at the right time:

1st. By careful and persistent spudding, done in such a way as to prevent the plant from developing top above the ground.

2nd. By early after-harvest cultivation of stubble ground.

3rd. By the frequent introduction of hoed crops into the rotation.

4th. By seeding much with clover, taking one or two crops of hay, plowing the clover sod shallow early after harvest, and cultivating frequently throughout the fall.

5th. By summer-fallowing.

Assuming that all land should be plowed in the fall, we may outline briefly one or two methods of destroying thistles:

(1) *In stubble ground for spring crop.* Gang-plow shallow and harrow early after harvest (immediately after the crop is off); and as soon as seeds have had time to sprout or thistles begin to appear, cultivate thoroughly with a broad-share cultivator, the points or shares overlapping far enough to cut all plants; and harrow again, to pull up and expose the plants that have been cut. Repeat the cultivation at intervals throughout the fall, and plow in the usual way, or, if possible, rib up with a double mould-board plow just before the frost. This systematic cultivation from harvest till winter, will check thistles and other weeds very much, and when followed by a hoed crop (mangels, corn, turnips, carrots, beans or rape), properly cultivated, it will not only clean the land, but put it into good shape for a crop of grain (oats, barley, etc.,) the next spring, which crop should be seeded with red clover.

FIG. 30.
CANADA THISTLE.
*(Carduus arvensis.)*

(2) *In sod (meadow or pasture) for spring crop.* After one or two, but not more than two, crops of hay or pasture, plow shallow (not more than four inches) early after harvest, say the 1st to the 15th of August, and harrow at once. Let it stand a couple of weeks, and then cultivate the same way it was plowed, two or three inches deep, with a spring-tooth cultivator. After a while cross-cultivate a little deeper. If possible, cultivate a third, or even a fourth time, going a little deeper each time. Then, if you can manage to do so, rib it up with a double mould-board plow the last thing in the fall This will make a good foundation for any crop the following spring—grain, roots, corn or rape—and if the portion in hoed crop is thoroughly cultivated with horse and hand hoes, very few, if any, thistles will be left. The portion intended for rape must be kept clean by surface cultivation till the time for putting in the crop, say the last half of June or the 1st of July, after which it should be treated like other hoed crops.

Some recommend a crop of fall rye on land which is intended for rape the following summer, but the rye takes so much moisture from the soil in the spring that the rape after it is apt to be a poor crop, unless in favorable seasons.

If summer-fallowing is resorted to, it will be well not to plow any more than is necessary, but to rely on surface cultivation with the broad-share cultivator and the harrow, done in such a way as to cut the plants two or three inches below the surface, without bringing up any of the numerous rootstocks which run along a little lower down. It will also be well to keep the fallow covered part of the summer by growing some kind of green crop, say a crop of buckwheat, sowed rather thick and plowed under when coming into bloom. This will help to prevent the loss of nitrates which bare land suffers from washing, and will improve the soil by increasing the supply of vegetable matter in it.

When necessary at any stage in the above method of cultivating either stubble-ground or sod, say for mangels, use a grubber or subsoil plow to stir the soil to a greater depth than is reached by the surface cultivation.

Fig. 31.

## Chicory, or Wild Succory.

*Cichorium intybus*, (L).

A perennial weed introduced from Europe, with long, deep taproot, which, when dried and ground up, is used in adulterating coffee and as a substitute for it. The stems are almost leafless, from 1 to 3 feet high, much branched, slightly hairy and whitish in color. The leaves, spread out on the ground, are long, with irregular edges. The flower heads are numerous, occuring in clusters, without flower stalks, on the naked branches. The flowers are about 1½ inches across, bright blue in color, and are usually closed by noon. The seed is about 1-8

FIG. 31.
CHICORY.
(*Cichorium intybus.*)

in. long, tapering to a blunt point, the opposite end having a fringe of minute hairs around the crown. The body of the seed is corrugated. An average plant produces about 3,000 seeds.

Time of flowering, July-October.

Time of seeding, August-October.

Dispersal—frequently as an impurity in clover and grass seed.

*Eradication.* The method outlined for Canada Thistle may be followed in eradicating this weed, but the plow may have to be used more frequently than is advisable in combatting thistles.

FIG 32.

## WILD LETTUCE, SOUTHERN THISTLE, OR TRUMPET-MILKWEED.
(Erroneously called Prickly Lettuce.)

*Lactuca Canadensis,* (L).

An annual or biennial plant with a leafy stem, which may attain a height of seven feet. The leaves are deeply lobed, terminating in an acute point, and have stalks or petioles, the lower ones being smaller than those near the top of the stem. The stem branches at its summit into a compound flower-cluster. The flowers are small, yellow in color, and open only a few at a time. The seed is dark brown in color, flat and oval, with longitudinal ribs and a thread-like beak at the apex, and possesses a small white tuft of hair (Fig. 32a).

Time of flowering, June-October.

Time of seeding, July-October.

Dispersal—chiefly by the wind.

*Eradication.* Where there is not much of it, pull and burn before ripening. Where this cannot be done, use the same method as for Mustard (Fig. 15).


Fig 32.
Wild Lettuce.
(*Lactuca Canadensis.*)

Fig. 33.

## Prickly Lettuce.

*Lactuca Scariola*, (L).

Prickly Lettuce is a native of the old world, and has invaded this Province both from New York and Michigan. It is a winter annual; it springs from seeds in the fall, and survives the winter. The plant grows to a height of 3½ feet; the stem is leafy and usually smooth; the leaves are oblong, and slightly pointed, often clasping at the base; the under surface of the midrib of the leaf is *spiny*: Heads are numerous and yellow.

Time of flowering, July-September.

Time of seeding, August-October.

Dispersal—By means of its seeds, which are provided with a pappus or tuft. An ordinary plant may produce 8,000 seeds.

*Eradication.* The best methods of destroying the weeds are: 1. To mow repeatedly as it comes into bloom, or earlier; 2. To cultivate thoroughly with a hoed crop. By this method the weeds in the soil will be induced to germinate. They should not be covered deeply in plowing. Mature plants should be cut down and burned lest the seeds be blown about and scattered by the wind.

Farmers should be careful to buy only clean clover, millet and grass seeds, and the weed inspector should insist on the fulfilment of the law, and have all fence-corners, roadsides, and waste lands cleared of the pest.


FIG. 33.
PRICKLY LETTUCE.
(*Lactuca scariola.*)

### Fig. 34.

### Orange Hawk Weed, Devil's Paint Brush.

*Hieracium aurantiacum* (L.)

A plant introduced from Europe, and a pernicious pest in pastures, meadows and roadsides in the eastern portion of the Province. The heads are bright red orange in color, and are clustered. The stems grow to a height of 12 inches. The leaves are oval, downy, and greyish-green in color. The seeds are provided with tufts of down, whereby they are scattered by the wind.

Time of flowering, June to August.

Time of seeding, June to September.

Dispersal—This plant is propagated by roots, runners and tufted seeds : also by seeds purchased in clover seed.

*Eradication.* Salt at the rate of 1½ tons per acre will kill this weed in pastures.

Fig. 87.
ORANGE HAWK WEED.
(*Hieracium Aurantiacum (L).*)

FIG. 35.

## ANNUAL SOW THISTLE, COMMON SOW THISTLE, OR MILK THISTLE.

*Sonchus oleraceus*, (L).

*and Sonchus Asper*, (Vill.)

An annual weed introduced from Europe. It grows 2-3 feet high, has fibrous roots and leafy stem, and is not quite so large or coarse as the Perennial Sow Thistle. The leaves are much lobed, and have short, soft spines. Each head is many-flowered; but the flowers are small, about ½ in. across, and of a pale yellow color. The seeds are brown, thin, and about 1-8 in. long, with longitudinal markings, and attached to the top is a large tuft of fine hairs united at the base.

Time of flowering, June-August.

Time of seeding, July-August.

Dispersal—chiefly by the wind.

*Eradication.* Cultivate stubble-ground and sod early after harvest and throughout the fall as for Canada Thistle (See Fig. 30.) Follow with hoed crop, preferably corn or roots, and cultivate thoroughly throughout the growing season. Use the cultivator, instead of the plow, after roots or corn; sow a crop of grain and seed with clover; if practicable, pull the weeds by hand out of the grain crop; take one or two crops of hay or pasture, and again break up the sod, plowing, harrowing and cultivating as for Thistle (Fig. 30).

Fig. 35.
Annual Sow Thistle.
*(Sonchus Asper.)*

FIG. 36.

## PERENNIAL SOW THISTLE, FIELD SOW THISTLE, OR CORN SOW THISTLE.

*Sonchus arvensis*, (L).

A perennial weed, 1 to 3 feet high, with large and vigorous rootstocks, full of a milky white juice. The stems are rough, and the growth of the lower part of the plant is rank. The leaves are deeply cut and furnished with small spines, and at their base clasp the stem. The flowers are bright yellow, of fair size, ½ in. across, and quite similar to those of the Dandelion. They close up in strong sunlight. The calyx, or flower cup, is green and covered with yellowish bristles. The seed is brown in color and about 1-8 in. long, with both longitudinal and transverse markings. To the top, a tuft of silken hair is attached (Fig. 36a.) An average plant produces about 2,000 seeds.

Time of flowering, June-August.

Time of seeding, June-August.

Dispersal—by running rootstocks, and the scattering of seeds by the wind.

The Sow Thistle draws much water from the soil and is a heavy feeder. It is less troublesome on stiff clays than elsewhere.

*Eradication.* The method used for the eradication of the Canada Thistle is recommended for this weed.

Fig. 36.
Perennial Sow Thistle.
(*Sonchus arvensis.*)

Fig. 37.

## Fleabane, or Horse Weed.

*Erigeron Canadensis*, (L.)

A tall hairy plant, very common in meadows. It is a winter annual. The stem is much branched and is hairy. The leaves are downy, from 1 to 4 inches long. The flower heads are numerous, about $\frac{1}{4}$ in. broad, with white flower rays. The seeds are small, light in color, and 1-16 in. long, with a pappus of short tufty hairs. An average plant produces 120,000 seeds (Kerner).

Time of flowering, June-September.

Time of seeding, June-September.

Dispersal—chiefly by the wind.

*Eradication.* Having a small root, this weed can be easily pulled. Hence, where there is not very much of it, hand-pulling is a satisfactory means of eradication. As a rule, the weed is troublesome only in meadows, and the frequent breaking up of meadow land tends to keep it under control.

Fig. 37.
Fleabane.
(*Erigeron Canadensis.*)

## Notes Concerning Other Noxious Weeds.

Corn Spurry, (*Spergula arvensis*, L). This is an annual with small white flowers, and is related to the chickweeds. It grows from 7 to 12 inches in height. The needle-like leaves are in whorls at the joints of the stem, and the plant is covered with clammy hairs. It grows mainly on sandy soil. Its effect is to smother the crop. It seeds very profusely.

*Treatment.* Frequent stirring of the soil to make the seeds sprout, and frequent harrowing to destroy the seedlings.

Tumble Weed, or White Pigweed, (*Amarantus albus*). This plant resembles Russian Thistle quite closely, but can be distinguished from it by its round, shiny, jet-black seeds, and by its leaves, which, although small, have a definite blade. It is a low branched annual when growing in sandy, open fields and roadsides.

*Treatment.* Prevent the maturing of the seeds which ripen in August. The plants as a rule are conspicuous, and may be readily collected and *burned*. The seeds are often found in grass-seed mixtures.

Lady's Thumb, or Smartweed, (*Polygonum Persicaria*). This plant grows to a height of 12 to 18 inches. Its leaves are lance-shaped, usually with a blotch near the centre. It is an annual, and is often abundant.

*Treatment.* Prevent from seeding, and sow clean seeds.

Toad Flax, or Butter and Eggs, (*Linaria vulgaris*. L). This is a perennial which has escaped from cultivation as an ornamental, and become a decided pest. It grows in tufts, and has bright, yellow, spurred flowers. It flowers from July to October, and seeds from August to November. It propagates itself by *root-stocks*, and by *seeds* in grass seed. It is found chiefly in meadows and roadsides.

*Treatment.* Continuous cultivation will subdue it, but care must be taken not to spread the root-stocks. Coal-oil, salt, etc., are effective after hoeing.

Wild Barley, or Squirrel-Tail Grass, (*Hordeum jubatum*). This pest is a native of the western prairies, but is invading the western parts of the Province. It has a dense head, like that of barley, and grows to a height of 12 inches or more. It is quite a serious pest in Manitoulin Island and the districts farther west. It should be gathered and burned wherever found.

Wild Tares, or Perennial Vetch, (*Vicia cracca*, L.). This is a perennial plant, with a deep system of root-stocks. It is often reported difficult of eradication. The flowers are blue, and there are 10 to 12 pairs of leaflets to each compound leaf. This plant appears to persist most tenaciously in damp soil. The same cultivation which is used in controlling the Canada and Perennial Sow Thistles will subdue the Perennial Vetch.

The Cinque-Foils, or Five Fingers. There are two or three species of Cinque-Foils which are becoming quite noxious. The large-flowered Cinque-Foil (*Potentilla recta*) is a perennial, with cream-colored flowers. The Norway Cinque-Foil (*Potentilla Norvegica*) is also a pest in many pastures. Cultivation, spudding, and hoeing will keep these plants under control.

Pigeon Weed, Wheat Thief, Red Root, or Corn Gromwell (*Lithospermum arvense, L.*) A winter annual naturalized from Europe, with reddish roots. It is usually branched, and grows to a height of 12 inches. The leaves are sessile, narrow, and harsh to feel. The flowers are small and white; at maturity, four small smooth seeds are produced, which have considerable vitality.

Time of flowering from April to July.

Time of seeding from June to August.

Dispersal—mainly through seed grain, such as wheat, rye, timothy, and alsike clover,—often spread by birds, and distributed in the manure.

*Eradication.* Drop fall wheat from the rotation. Cultivate lightly after harvest and cause the seeds to germinate. When three or four inches high, harrow or plow them under. If this treatment is repeated each fall, wheat can again be grown.

Sweet Clover (*Melilotus alba*). The white sweet clover is a very common plant in vacant grounds and neglected fields about cities and along roadsides. It is a tall, rank growing plant, and thrives best on heavy clay soils. It may be classed among the weeds, inasmuch as it grows where it is not wanted, but it cannot be considered a noxious weed. As a soil-former sweet clover is a valuable plant. It roots deeply, and is a nitrate producer. With the aid of the rains and frosts it gradually mellows the soil of unproductive clay, and makes it fit for cultivation.

It is a biennial. The shoots of the first year's growth are tender, and are valued in the South as fodder for stock, but those of the second year are tough, fibrous, and branching, and bear the flowers which are very attractive to honey bees. In some districts sweet clover is grown extensively by apiculturists. The number of seeds produced every year by each plant is very large. Experience shows that sweet clover is not difficult to control. It grows altogether from the seed. If seeding is prevented by cutting down the plants at blossoming time very few plants will make their appearance the following season.

Although a fodder plant in the South, sweet clover is not relished by stock in Ontario. On account of the tough, fibrous structure of the second year's growth there is a possibility that the plant may in a few years be grown for the manufacture of binder-twine, etc.

# INDEX.

BULLETIN 129 December, 1903

Ontario Agricultural College and Experimental Farm.

# BACON PRODUCTION.

By G. E. Day, Professor of Agriculture and Farm Superintendent.

## PART I.—BUILDINGS.

The question of buildings for swine is such a complicated one that it seems a hopeless task to attempt a discussion of the subject. Almost every piggery that is built possesses certain features peculiar to itself, and rendered necessary by the circumstances which it is intended to meet. All that will be attempted here, therefore, is a brief discussion of the desirable features of a piggery, illustrated by drawings of a cheap and convenient building which may be modified to meet almost any requirements.

The most important requirements of a piggery are dryness, ventilation, light, freedom from draughts, reasonable warmth, and convenience.

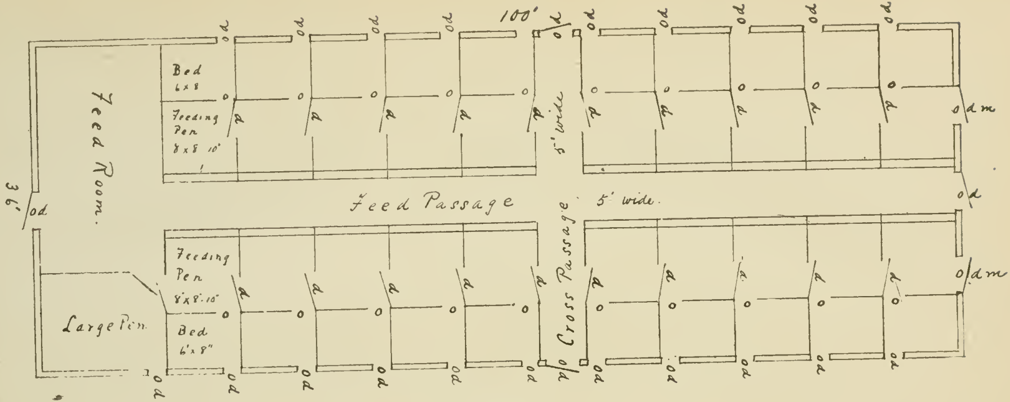
Dryness. Dryness is closely associated with ventilation, but is also influenced by the material of which the building is constructed. Good results can not be obtained in a damp pen; and dripping walls are a pretty sure indication of impending disaster. Rheumatism and numerous forms of unthriftiness result from dampness. Stone and cement walls are very cold in winter, and chill the air of the pen, causing it to deposit its moisture upon their surface. In a short time the wall becomes quite wet, and trouble is stored up for the pigs. A hollow cement wall is much less objectionable than a solid one; but our experience leads us to prefer wooden walls, constructed in such a way as to form a complete dead air space in the centre.

Ventilation. Thorough ventilation is a great help in preserving dryness; but it is a difficult thing to secure in a piggery without unduly lowering the temperature. It is a great aid to ventilation to provide a large air space, or, in other words, to have a high ceiling. The tendency at present is to do away with the common loft over the piggery, and to have the space above the pigs extend to the roof. This gives more air space, and makes ventilation a simpler problem. The admission of fresh air can be provided for by constructing shafts in the walls at intervals of fifteen or twenty feet. These shafts open outside near the ground, and inside, at the ceiling. Provision should be made for the closing, or partial closing, of these intakes when cold air is admitted too rapidly. Windows in the roof, as described in the plan, are a very effective means of removing foul air.

Light. Light, especially sunlight, has a wonderful influence in promoting health. So far as possible, the windows should be on the south side of the building, as the south side gets most sun, and is least exposed to cold winds.

Draughts. While ventilation is necessary, draughts are extremely injurious, and their prevention should be kept in view when building.

Warmth. Warmth is a good thing; but it should not be secured at the expense of ventilation. A somewhat cold pen, well ventilated but free from draughts, is preferable to a warm pen where the air is damp and foul, and the pigs will suffer less discomfort in the former than in the latter.



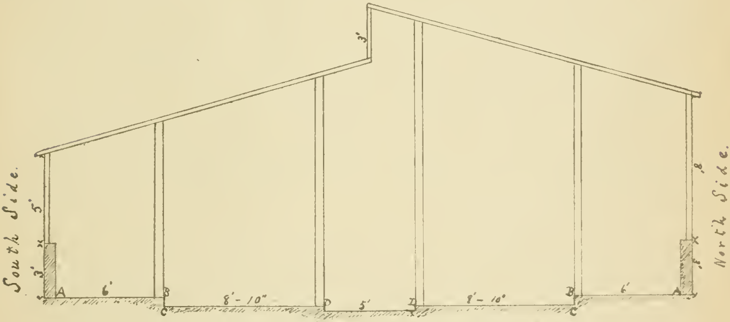

Plan of Piggery.

*Explanations :* o. Openings $2\frac{1}{2}$ feet wide between bed and feeding pen.
d. Doors 4 feet wide in partitions, which swing back and close openings at o.
o d. Doors leading outside.
o.d.m. Doors for taking out manure, or taking in bedding.
Pens are uniform size throughout. Dimensions of pens include partitions.

### Plan of Piggery.

The plan which is given here is taken from a new piggery built this year by Mr. J. E. Brethour, Burford, Ont. Its construction is comparatively cheap, and its possesses many desirable features. It is capable of many modifications; and a careful study of the plan will be helpful to those who intend to build. Of course, the building can be made any length desired.

The building is 36 x 100 feet, outside measurement. A cement wall 8 inches thick rises 3 feet above the floor. On top of this wall the frame is built. The walls are built of 2 x 4-inch studding, boarded on the outside with cheap lumber, covered with building paper and tightly clap-boarded on top of the paper. On the inside, the walls are lined with matched lumber, so as to form a dead air space inside. The lining also extends over the lower side of the rafters, giving a dead air space to the roof, as well as the walls.




Cross section of Piggery, showing contour of floor, shape of roof, and supports for same.

From the cross-section it will be seen that the total height of the wall on the north side is 11 feet and of that on the south side 8 feet. The roof has the same pitch on both sides, so that there is a drop of 3 feet from one section of the roof to the other, at the centre of the building. In this space windows are inserted to throw light and a certain amount of sunshine into the row of pens along the north side of the building. These windows are hinged at the bottom and can be opened at any angle according to the requirements of ventilation. A ratchet device, similar to that used for opening the ventilators in greenhouses, would be very convenient for this purpose.

The floor is cement. Cement is so durable and so easily cleaned, that it seems to be about the only satisfactory floor. The part A B (see cross-section) is 6 inches higher than C D. There is a fall of 1½ inches from A towards B, and a fall of 3 inches from D towards C. Thus all the drainage is towards C, the lowest point; and the bed, being on top of A B, is always dry.

There is a partition 3½ feet high between the bed and the feeding pen, and the opening from the bed to the feeding pen is 2½ feet wide. The partition shelters from draughts, and also economizes bedding by holding the straw in place. The other partitions are 4 feet high. The partition next to the feed passage is made of No. 9 coil steel wires, 2 inches apart at the bottom and grading to about 3 inches apart near the top. They are stiffened by a heavy upright wire in front of each pen, fastened to the horizontal wires by means of washers used for that purpose. The wire partition is set in about 2½ inches from the side of the trough next to the passage, thus allowing room to pour feed into the troughs.

The troughs are cement, and are 8 inches high next to the feed passage, 4 inches high next to the feeding pen, and 10 inches wide.

The feed passage, which is 5 feet wide, is 4 inches lower than the feeding pen. This is merely a device to show the pigs to better advantage.

The purpose of the doors in the partitions between the pens is easily understood. They can be swung back, closing the pigs in the back apartment and leaving a continuous passage for cleaning out the pens. The bedding is also taken in and distributed from this passage. These doors are also used in moving pigs from one pen to another, since there are no doors from the pens into the feed passage. The absence of doors from the pens into the feed passage is one of the most inconvenient features of the pen, but is hard to avoid where a wire partition is used. The wire partition, however, is more sanitary than wood and gives a much better view of the pigs.

It will be noticed that the sleeping quarters have cement floors. When bedding is plentiful this may give no trouble, but it would be a simple matter to place a portable wooden platform on the cement.

The roof is supported by the four lines of posts to which the partitions are fastened. Each row carries a line of plates which support the rafters.

There are six windows, each 5 feet long by 2½ feet high, in the south wall, and the same number in the roof, placed as previously described. The north wall has only two windows.

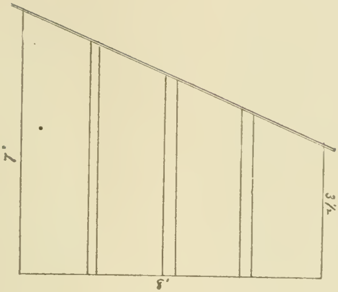
The dimensions given for the small pens, include partitions.

The pens as described are not suitable for farrowing pens. As a matter of fact, it is better to have sows farrow in a building away from other pigs, especially during cold weather when the building must be kept pretty well closed up. The air of a piggery where a large number of pigs are kept, does not seem to agree well with little pigs. However, if it were desired to have the sows farrow in the large piggery, one of the sections on the south side could be modified to answer the purpose by making the sleeping apartments 2½ feet wider, thus giving beds 8 x 8½ feet.

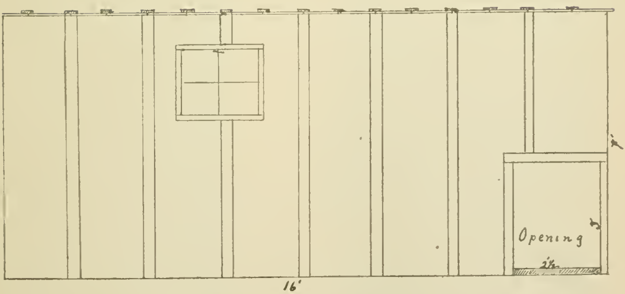
The absence of a loft for storing straw will be a strong objection in the eyes of many. The ventilation of the building, however, and the health of the animals are of vastly greater importance than the inconvenience occasioned by the absence of a loft. It is generally possible to locate the building so as to make it comparatively easy to obtain straw for bedding.

## Portable Pens.

The accompanying sketches show a very cheap and easily constructed pen, suitable for winter quarters for breeding sows. The pen is 16 feet long by 8 feet wide. It is 7 feet high in front and 3½ feet high at the rear. It is boarded with cheap lumber, but all cracks are securely battened. It should be practically wind and rain proof. The opening is at one corner; and the pen should be set with the opening towards the south. A door is not necessary. Plenty of bedding should be supplied, and the pen should be banked outside with horse manure to the depth of about two feet. This method of housing sows is better than close confinement in warm pens. The same pens will answer for shelter from the sun in summer.




End view of Portable Pen.



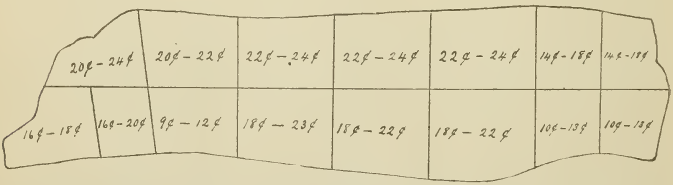

Front view of Portable Pen.

## PART II.—THE CANADIAN EXPORT TRADE.

In the United States there is an immense home market for lard and oleomargarine (artificial butter). In Canada we have no trade in oleomargarine, and a very much smaller home market for lard. The American packer, therefore, can utilize very fat hogs, manufacturing lard and oleomargarine from the fat and placing only the leaner carcases and the lean parts of the fat carcases upon the market to be consumed as meat. On the other hand, practically all the Canadian hogs must be consumed as meat; and as there is a very limited and decreasing demand for fat pork the production of a leaner class of hog has become a necessity in Canada. Great Britain is the home of the export trade in pork products of both Canada and the United States, the latter country exporting vastly larger quantities than Canada; and to keep out of a hopeless competition with the Americans our packers have been forced to cater to an entirely different class of customers. Thus it comes that the lean and carefully prepared bacon of Canada is taken by the large cities and retailed to the well-to-do classes, while the American product goes mainly to a less fastidious class of customers at a lower price. Canadian bacon, therefore, does not come into direct competition with the bulk of the American product in Great Britain; and a very little consideration of facts outlined above should convince any thoughtful person of the importance of avoiding American competition as far as possible. As a matter of fact, we are compelled to go out of the fat hog business, owing to the vast advantages possessed by the Americans in the way of markets for their products.

The kind of bacon of which Canadian packers make a specialty is what is known as the "Wiltshire side." Denmark and Ireland are our main competitors; but their conditions are somewhat similar to our own, and the competition, therefore, is not a hopeless one. At the same time, we need to put forth every effort if we are to hold our own in the British market; and hence we require to give the subject of bacon production most careful study.

To make Wiltshire sides, a hog is required weighing from 160 to 220 pounds, live weight. These are not cast-iron limits, though 160 pounds is rather too light for making the best side. The most suitable weights are from 180 to 190 pounds. The diagram which follows shows a retail dealer's method of cutting a Wiltshire side and the approximate retail values in Great Britain.




A Wiltshire Side,
Showing retail dealer's method of cutting, and approximate range of retail values in Great Britain.

The diagram shows that the most valuable meat is found along the upper part of the side as far forward as the shoulder. When the shoulder and neck are reached there is a very material drop in the value. This teaches that the hog with a heavy, rough shoulder produces a very undesirable side, because it gives a side which is heavy at the cheap end. It teaches further that the hog should have good length from the back of the shoulder to the ham, because this is the most valuable part of the side of bacon. It will be noted

Fig. 1. No. 1 selection

Fig. 2. Fat.

also that the belly meat is cheaper than the part above it, and this explains why we require the bacon hog to have a trim belly and a straight underline.

The figures given on page 7 are from photographs of sides from hogs used our breed experiments.

Fig. 1 shows a No. 1 side. Note the uniformity in thickness of the layer of fat along the back. This layer of fat should be from 1¼ to 1½ inches in thickness, and should be practically the same thickness from loin to neck. The side is very uniform in depth also, and does not show undue weight or shoulder and neck. Compare this with Fig. 2, which represents a fat side. There is too much fat all along the back, and the fat arches considerably over the shoulder. If these two sides are compared with the diagram, it will be seen at a glance how much more cheap meat is shown in Fig. 2 than in Fig. 1. The side shown in Fig. 2 came from a hog possessing a heavy, arching neck, a broad shoulder, broad, fat back, and a deep, heavy belly.

The conformation required for bacon production is described more fully under selection of boar and sow.

## PART III.—BREEDING FOR BACON.

To produce the best type of hog for bacon production, care must be taken in the selection of breeding stock. There are those who claim that it is practically all a matter of feeding; but this is a very serious mistake. It is true that by careful feeding an objectionable type of hog can be greatly improved, but it can never be made to produce an ideal side of bacon. To produce the best bacon, both the breeding and the feeding must receive careful attention.

### BREEDS OF SWINE.

In 1896 an experiment was commenced for the purpose of comparing six breeds of swine, both as regards economy of gain and suitability for the export trade. The breeds used were Berkshire, Yorkshire, Tamworth, Chester White, Poland China, and Duroc Jersey. The experiment was repeated in 1897, 1898, 1899, and 1900, making five carefully conducted tests. In each of the five years, six pigs of each breed were used for the test. In 1901 the same breeds were again fed under the same conditions, using a larger number of each breed. This experiment, however, was conducted for the purpose of comparing outside with inside feeding, and no attempt was made to compare the relative cost of production in the different breeds. The breeds were compared however as to suitability for export.

Altogether, therefore, we had five experiments in which the six breeds were compared as to cost of producing 100 pounds gain, live weight; and six experiments in which the six breeds were compared as to their suitability for export.

### THE RELATION OF BREED TO ECONOMY OF PRODUCTION.

The table given below shows the average amount of meal required for 100 pounds gain, live weight, in the five experiments. In the making up of this table only the meal has been considered. Such foods as dairy by-products and green feed, which were fed sometimes, were the same for all breeds, and have been omitted to simplify the comparison.

The following shows the average amount of meal consumed for 100 pounds gain, live weight, in five experiments:

| | Pounds. | | Pounds. |
|---|---|---|---|
| Berkshire | 364.45 | Duroc Jersey | 384.23 |
| Yorkshire | 369.51 | Chester White | 387.89 |
| Tamworth | 380.47 | Poland China | 391.42 |

Before any conclusions are drawn from the table given above, a second table will be presented for consideration in connection with it. This table shows the standing of the breeds for each year, each column being ranked in order of economy of gain:

Table showing the different breeds ranked in order of economy of gain for each year of the experiment:

| 1896. | 1897. | 1898. | 1899. | 1900. |
|---|---|---|---|---|
| Berkshire. | Berkshire. | Yorkshire. | Berkshire | Berkshire. |
| Tamworth. | Tamworth | Berkshire. | Tamworth. | Yorkshire. |
| Poland China. | Poland China. | Duroc Jersey. | Yorkshire. | Duroc Jersey. |
| Duroc Jersey. | Chester White. | { Tamworth. | Chester White. | Chester White. |
| Chester White. | Yorkshire. | { Chester White. | Duroc Jersey. | Tamworth. |
| Yorkshire. | Duroc Jersey. | Poland China. | Poland China. | Poland China. |

In considering these tables we must bear in mind that averages are frequently misleading. For example, in a certain experiment one breed may suffer from some unfavorable circumstance which is in no way related to, or influenced by the breeding of the animals; yet this circumstance may seriously affect the average standing of the breed in question.

A study of the last table reveals the fact that there is little or no constancy in the standing of any one breed, except the Berkshires, which certainly make a remarkably good showing. It may be possible that the Berkshires were able to digest and assimilate a larger percentage of their food than were the other breeds, but we believe that, at least, a large share of their success was due to another cause. All the pigs used in these experiments were purchased at ages varying from six to ten weeks, and it was noted that the Berkshires seemed to adapt themselves to the new conditions and change of food more readily than any of the other breeds, and thus scored an advantage at the commencement of the experiment, which they generally held until the close. We are inclined, therefore, to attribute their high standing to their ability to adapt themselves to changed conditions, rather than to their power to digest and assimilate a larger percentage of their food.

Everything considered, we are led to the belief that there is little, if any, relation between breed and power to digest and assimilate food, and that individuality is the all-important factor in this connection. To produce bacon cheaply we require a healthy, thrifty, growthy pig. Whether its color is red, white or black; or whether its ears are erect or drooped, are largely matters of taste.

### Relation of Breed to the Export Trade.

It has already been stated that we had six experiments, in which six breeds of swine were compared as to their suitability for producing export bacon. In each experiment the hogs were shipped to the Wm. Davies Co., Toronto, where they were slaughtered and the carcases critically examined by an expert, who was given no information as to the breeds which they represented. The table given below shows the different breeds ranked according to suitability for the production of "Wiltshire sides."

| 1896. | 1897. | 1898. |
|---|---|---|
| 1. Yorkshire.<br>Tamworth.<br>3. Berkshire.<br>4. Duroc Jersey.<br>Poland China.<br>Chester White | 1. Yorkshire.<br>2. Tamworth.<br>3. Berkshire.<br>Chester White.<br>Duroc Jersey.<br>Poland China. | 1. Yorkshire.<br>Tamworth.<br>3. Berkshire.<br>4. Poland China.<br>5. Chester White.<br>Duroc Jersey. |

| 1899. | 1900. | 1901. |
|---|---|---|
| 1. Yorkshire.<br>2. Tamworth.<br>3. Berkshire.<br>4. Chester White.<br>Duroc Jersey.<br>Poland China. | 1. Yorkshire.<br>2. Berkshire.<br>3. Chester White.<br>4. Tamworth.<br>5. Duroc Jersey.<br>6. Poland China. | 1. Yorkshire.<br>2. Tamworth.<br>3. Berkshire.<br>4. Duroc Jersey.<br>5. Poland China.<br>Chester White. |

From this table is will be seen that the Yorkshires had a very distinct advantage in this part of the experiment. The Yorkshire carcases were characterized by good length of side, uniformity in thickness of fat along the back, a good general development of flesh (lean), thickly fleshed loin, thick, fleshy belly, and a fleshy ham which required little trimming. Their most serious faults ran in the direction of an undue weight of shoulder, coarseness of bone and thickness of skin, though these defects were noticeable in only a small proportion of the carcases.

The Tamworths generally had a light shoulder and a very uniform layer of fat along the back; but, as a rule, they did not quite equal the Yorkshire in length of side, thickness of loin and belly, and development of ham. In many of them there was a marked lack of flesh over the loin, accompanied by a thinness of belly and a decided lightness of ham.

The strong point of the Berkshire carcases was their large muscular development, giving a fleshy carcase. The ham was well developed; but, in many cases, it carried too much fat and required considerable trimming. The main faults were the shortness of side and an undue weight of shoulder, with the fat running very thick over the shoulder top. There was, moreover, a marked lack of uniformity in the Berkshire carcases, some of them making capital Wiltshire sides, while others were entirely unsuitable. The Yorkshire carcases, on the other hand, were specially noted for their uniformity.

The Chester White, Poland China and Duroc Jersey carcases were very similar in character. Occasionally a good Wiltshire side was found among them; but it was a noteworthy exception. Shortness of side, a superabundance of fat, and a lack of flesh were generally characteristic of the group.

### Relation Between Bacon Type and Economy of Production.

The results of our experiments are in direct opposition to the theory that it costs more to produce a pound of gain in a hog of the bacon type, than in one of a thick, fat type. It is true that the Berkshire made a better showing in regard to economy of gain than the Yorkshires and Tamworths, which scored highest in the slaughter test; but it is also true that the Berkshires were much superior as bacon hogs to the Duroc Jerseys, Poland Chinas and Chester Whites, and stood higher in point of economy of gain. The last three breeds were the least suitable for export; and they also stood at the bottom of the list in point of economy of gain. If the tables given above prove nothing else, they certainly demonstrate very clearly that a hog of good bacon type can be fed just as cheaply as one of an undesirable type. This also applies to animals of the same breed, but of different types.

### Selection of the Boar.

It is perhaps unnecessary to say that the boar should be pure bred. The pure-bred male will transmit his own qualities to his progeny and produce pigs more uniform in character than will a grade or a cross-bred. Not only should he be pure-bred but he should be well-bred; that is to say, he should belong to a family noted for its general excellence in the qualities which we desire to reproduce. In addition to these things he should himself possess those qualities which we wish to see in his progeny. A boar of this description is likely to give satisfactory results.

### Bacon Type in Boars.

In the first place a boar should show male character and give indications of strong constitution. He should have good width between the fore legs and be thick through the heart, or just back of the elbow. He should be deep from the top to bottom back of the shoulder; and the space back of the shoulder should be well filled out, giving a good heart girth. The jowl should be broad and strong, but not fat and flabby; the forehead broad, and the poll broad and full. The neck should be of medium length and strongly muscled, but should show no heavy crown of fat. The eye should be large, full and bright, and his general appearance should indicate alertness and activity.

The shoulders are heavier than would be desirable in a sow or barrow; and as he grows older "shields" develop on the sides, which often give the appearance of roughness. He should be very compact on top, however, and blend well with the top line and the rib at this point. The bacon type shoulder is upright, making the animal comparatively short from the back of the shoulder to the head, and long from the back of the shoulder to the ham. This formation gives the largest development where the meat is most valuable.

The spring of rib is very characteristic. It should arch out boldly from the backbone, then suddenly drop in an almost vertical direction, giving a flat, straight side. This point should receive special attention in making a selection, for it is a sure indication of a strong development of muscle along the back; and muscle is lean meat.

The top line should rise slightly above the straight line, giving a very slight arch, the highest point of which is over the loin. The back should be of medium width and uniform in width throughout. The loin should be as wide as the rest of the back and be full, strong and heavily muscled. The rump should be the same width as the back and loin, slightly rounded from side to side over the top, and from the hips to the tail. The ham should taper towards the hock and carry the flesh well down towards the hock, especially on the inside of the shank.

The underline should be trim and straight, showing no tendency towards a sagging belly; and the hind flanks should be full, giving good thickness through at this point.

The legs should be of medium length, and the bone heavy, but clean and presenting a flattish appearance. Rough, puffy legs are very undesirable; and it is also a serious objection to have the bone fine. The pasterns should be upright, so that the animal walks well up on his toes. A hog with weak pasterns should not be bred from.

The hair should be abundant, but not coarse. A row of bristles standing up along the neck and over the shoulder top is extremely objectionable.

The carriage should be easy, the animal walking without apparent exertion, and without a swaying movement.

### Selection of the Sow.

For the production of bacon it is not absolutely essential that the sow be pure bred. A grade sow of good type will usually produce very good pigs for bacon purposes, provided the boar is such as has been described in regard to breeding and quality. Many feeders prefer a cross between two distinct breeds; and, no doubt, this method has produced many excellent pigs. What is the best cross will probably never be known, as it is largely a question of the individuality of the animals used. We have crossed the Yorkshire and Tamworth with the Berkshire and Chester White with very good results; and we have also crossed the Yorkshire with the Tamworth with very fair success. As yet, however, we have conducted no systematic experiments in cross-breeding.

A sow should be selected from a prolific mother, because fecundity is hereditary. The number and development of the teats should also be noted; and at least eleven fully developed teats should be insisted upon. The teats should be set well apart, and the front teats should be well forward on the body.

Bacon Type in Sows. The sow is finer in head, neck, shoulder, and bone than the boar. Outside of these points, the description given of the boar will also apply to the sow. Extremes should be avoided. A long, scrawny neck, narrow chest, and long coarse legs, indicate a slow feeder and an undesirable quality of bacon. The carcase of such an animal contains too much bone, and is deficient in muscle, or lean meat. The thick, short type is also undesirable; and the best bacon type is a mean between two extremes. Though coarse bone is bad, it will not do to go to the other extreme and select very fine bone. The bone should be clean and strong; and there should be enough of it to insure a good-sized animal. Weak bone, which tends to break down at the pasterns, should not be tolerated.

## PART IV.—FEEDING FOR BACON.

Soft Bacon. If we are to maintain and develop our trade in bacon with Great Britain, it is of the greatest importance that we pay strict attention to quality. Not only must our hogs be bred to give the desired conformation; but they must be fed and managed in such a way as to give the desired quality. One of the greatest defects in quality with which our packers have to contend, is a tendency of some sides to turn soft during the process of curing. Softness has nothing to do with fatness; in fact, a thin side is more apt to develop softness than a fat one. In a soft side, the fat is soft and spongy; and sometimes even the lean is affected. There are all degrees of softness up to a mere slight tenderness; but any degree of tenderness detracts very much from the value of a side; and a really soft side is practically worthless. The percentage of soft sides is sometimes very high, even as high as 40 per cent. of the total at certain seasons of the year. It will, therefore, be easily understood that such a condition represents an enormous shrinkage in value; and this loss is bound to be reflected in the prices paid the farmer for his hogs, to say nothing of the injury to the reputation of our bacon in Great Britain. This is not a matter, therefore, which affects merely the packer. It affects the bacon industry as a whole; and the farmer, sooner or later, must shoulder the loss. It is important, therefore, that the farmer should pay particular attention to the question of quality.

### Causes of Soft Bacon.

To describe all our experiments under this head would occupy too much space, and would be found tiresome, and perhaps confusing, to the average reader. The conclusions which follow are based upon a careful analysis of our work to date, descriptions of which have been published from year to year in the annual report of the college. We have also been able to draw upon considerable unpublished data.

Exclusive Meal Feeding. This is perhaps one of the most common causes of softness, especially when hogs are confined in pens from birth to the time of marketing. Some kinds of meal are more dangerous than others; but wherever exclusive meal feeding is practised, and the exercise is limited, more or less softness is almost sure to result.

Corn and Beans. Of the grains in common use, corn has the greatest tendency to cause softness. Its injurious tendency can be modified by mixing it largely with other meal, and by feeding skim milk, green foods, and roots; but its tendency to produce softness is so strong that it must be regarded as an undesirable food.

We have not experimented with beans; but the Central Experimental Farm at Ottawa found that beans have an effect similar to corn.

Lack of exercise. Lack of exercise has a tendency to produce softness; but this tendency can be largely overcome by judicious feeding.

Unthriftiness. Unthrifty hogs, no matter what the cause may be, invariably produce soft bacon.

Lack of finish. Thin hogs have a marked tendency towards softness. Marketing hogs before they are properly finished, is no doubt responsible for a good deal of softness.

Holding back. When a hog is finished, it should be marketed at once in order to produce firm bacon. If the feed is cut down, so that the hog makes no gain in weight for some time, or loses in weight, the bacon from such a hog is almost sure to be soft.

## Production of Firm Bacon.

From what has been said, it will be seen that softness may result from a number of causes; and it is possible that there are causes outside of those mentioned. Enough has been said, however, to place the feeder on his guard against the most common causes; and below are offered a few suggestions regarding methods of feeding, and management which we have found to give good results.

Feeding. As already stated, exclusive meal feeding is apt to injure the quality of bacon. We have also found that it does not give so economical gains as a mixed diet. Among the foods which we have used along with meal, are skim-milk, whey, roots, rape, vetches, and clover. We have found that these foods, combined with a liberal meal ration, invariably give better gains than an exclusively meal ration, and produce a better quality of bacon. It is probable that much of the beneficial influence of these foods is due to the fact that they help to keep the animals healthy and thrifty, a condition necessary to the production of the best quality of bacon.

But while these succulent foods have an important place in hog feeding, they may also be abused. If an attempt is made to feed hogs almost exclusively upon them, the chances are that the hogs will not be properly finished, and soft bacon will likely result. The use of various foods will be found more fully discussed under "Notes on Foodstuffs."

Exercise. In our experiments, we have found that unlimited exercise during the fattening period is not conducive to cheap production. At the same time, the exercise has a good effect upon the firmness of the bacon produced. We have secured our cheapest gains, and an excellent quality of bacon from allowing the hogs only a limited amount of exercise in small outside yards adjacent to the pens, and feeding a limited ration of mixed meal accompanied with all the green food they will eat. By a limited meal ration, is meant an allowance slightly less than the hogs will eat if given the opportunity. We have found this method more economical than feeding meal on pasture, though it requires more labor. It is a notable fact, however, that hogs which have run at large until they weigh 100 pounds in thin condition, may be finished on almost any meal mixture and still produce firm bacon. This fact illustrates the marked influence of exercise upon firmness of bacon.

## Notes on Foodstuffs.

It will invariably be found that a mixture of foods gives better results than a single kind. In the notes which follow, some of the principal pig foods are briefly discussed, and suggestions given regarding their combination with other foods.

Peas. Whole peas are very palatable, but entirely too wasteful, as the hogs do not digest them thoroughly. Pea meal is a valuable food, but should never be fed alone. The heavy, close nature of the meal renders it difficult to digest, and the pigs are very apt to sicken. It combines well with barley, or barley and wheat middlings. A few well ground oats may also be added. Peas are noted for the excellent quality of bacon wihch they produce.

Barley. This is a noted hog food in Europe; but some feeders in this country do not look upon it with favor. We have secured excellent results from barley, however, both in the amount of gain and the quality of bacon. For young pigs it should be mixed with wheat middlings, a very little barley being used at first, and the quantity gradually increased. For older pigs, peas or wheat may be added. Some succulent food, such as roots or green food, should always be fed with it; and skim-milk makes a great improvement. It is not generally regarded with favor as a food for breeding sows.

Wheat. This grain has a higher feeding value than barley, but requires mixing with other meal to get the best results. It combines very well with barley, or barley and middlings.

Oats. Owing to the amount of fibre in this food, hogs cannot digest it so well as can cattle. Oats are more suitable for matured breeding stock than for young or fattening pigs, though a few finely ground oats may be used in a mixture to give variety, and to lighten heavier meal, such as that from peas, wheat, or corn. For young pigs, they are better to have the coarser hulls sifted out.

Rye. Rye has a feeding value a little lower than wheat, and a little higher than barley. It may be used in practically the same way as wheat.

Corn. This is a fattening food, and is not conducive to the development of bone and muscle. When fed alone, it gives poor results in producing gain in weight; and its bad influence upon the quality of bacon has already been described. If fed at all, it should be mixed largely with barley or middlings, or both; and some form of succulent food or skim-milk should always be fed with it. Owing to its tendency to produce soft bacon, it should be used as little as possible for hog feeding, when bacon production is the object.

Middlings. This by-product is also called shorts, though some millers make a distinction between shorts and middlings. It is almost universally used for young pigs, and mixed with skim-milk when such is available. If very floury, it is safer to mix a little bran with it, or some finely ground oats with the coarser hulls sifted out, when used for very young pigs; otherwise it sometimes causes indigestion. Soaking for a few hours, or scalding, improves it for young pigs. It combines well with almost any kind of meal, and makes a good food for pigs of all ages.

Bran. The use of bran in pig feeding is rather limited. It contains too much fibre, and is rather too bulky to be fed in large quantity to pigs. Sometimes a little of it can be used to advantage for the purpose of diluting or lightening other foods, as has been indicated. It can be used in larger quantity for matured breeding stock, where the object is to hold the animals in light breeding condition.

Skim-milk. With the exception of whole milk, there is perhaps no food better suited to pigs of all ages than skim-milk. It is especially beneficial in the case of young pigs, and tends to promote the development of bone and muscle. For fattening purposes, milk has been found to have the greatest feeding value per 100 pounds, when not more than three pounds of milk are fed for each pound of meal. Fed in this way, as low as 327 pounds of skim-milk have proved equal to 100 pounds of meal. This is an exceptionally good showing, however. In Danish experiments, it required, on an average, about 600 pounds of milk to equal 100 pounds of meal; but in these cases a very much larger proportion of milk to meal was used than the proportion mentioned above. In feeding skim-milk, therefore, the feeder must take into account the relative cost of milk and meal, in deciding what proportions to feed.

A strong point in favor of skim-milk. is the excellent quality of bacon it produces. It tends to correct the evil influences of corn, when fed in conjunction with that food; and our experience is that when it is used, hogs produce firm bacon though kept in comparatively close confinement.

Whey. Though unsuitable for very young pigs, a limited amount of whey gives very good results after the pigs are three or four months old. We have obtained the best results from whey feeding by using only enough whey to make the meal into a thick slop. When fed in this way, we have found that it requires from 12 to 14 pounds of whey to be equal in feeding value to one pound of meal. This is a very much higher feeding value for whey, however, than can be expected when it is fed in large quantity.

Its influence upon the firmness of bacon was very satisfactory; and it appeared to correct the bad influence of lack of exercise.

Sugar Beets. Hogs seem to prefer sugar beets to almost any other kind of roots. Some difference of opinion exists regarding the amount of roots that may be fed with profit to hogs. They should be fed in limited quantity to small pigs; but pigs weighing over 100 pounds live weight, will, in some cases, take five or six times as much roots as meal, by weight, and make very good gains. We have obtained our best results, however, from feeding equal parts by weight of roots and meal. The proportion of roots may be increased considerably, if thought advisable, as the hogs advance in weight.

In all our experiments, we have obtained very satisfactory results from root feeding, so far as firmness of bacon is concerned.

Mangels. Though not quite so high in feeding value, mangels compare very favorably with sugar beets for hog feeding. If the hogs have not been fed sugar beets, they will eat mangels very readily. Their influence upon the firmness of bacon is the same as that of sugar beets.

Turnips. Hogs are not so fond of turnips as of mangels and sugar beets; but if they do not know the taste of either mangels or sugar beets, they will eat a considerable quantity of turnips. Turnips are made more palatable by cooking, though it is doubtful whether cooking increases their actual feeding value, which is very similar to that of mangels. We have found the feeding of turnips along with a meal ration to give a firmer quality of bacon than when meal is fed alone.

Potatoes. Cooking is essential in order to get the best results from potatoes. If they can be cooked so as to leave them dry and mealy, hogs will eat them much more readily. They make a very palatable food when mashed and mixed with meal. Their influence upon the quality of bacon is also beneficial.

Artichokes. In some sections, this crop is very popular as a hog food. It is suitable, however, only for somewhat light, sandy soils. Artichokes may be planted in the late fall or early spring, in rows 21 to 24 inches apart, and from 12 to 18 inches apart in the rows. They are usually ready to feed about September 15th, and the hogs are turned in to dig them for themselves. Frost does not injure them, and usually enough are left in the ground for another crop, if it is thought advisable to leave them. When it is desired to eradicate them, the hogs may be turned on them again in the spring, and the plot subsequently sown with turnips.

Artichokes have a little higher feeding value than potatoes, and hogs are very fond of them.

Feeding Value of Roots. As has already been intimated, much of the feeding value of roots consists in their action upon the general health of the animal. They tend to prevent indigestion and constipation, and to promote general thrift. The results of our experiments, and of those conducted by other experiment stations, indicate that from 6 to 8 pounds of sugar beets, mangels, or turnips, are equivalent in feeding value to one pound of mixed meal; and that 4 to 4½ pounds of potatoes are equivalent to one pound of mixed meal. The meal equivalent of roots varies considerably, depending upon circumstances; but the figures given will serve as a general guide.

Rape. This is an exceptionally valuable food for swine, and may be pastured, or cut and fed to the pigs in pens. For fattening hogs, we have obtained best results from feeding about a two-thirds meal ration, and all the rape the hogs will eat. The hogs were kept in pens with small outside yards, and the rape was cut and carried to them. This method of feeding gave more economical gains than fattening on pasture, and the bacon was of equally good quality.

For breedin‗ ~ws, however, pasturing the rape is preferable, owing to the exercise it gives ~imals. When on rape pasture, matured sows require little other food.

Young, growing sows, however, require a fairly liberal meal ration in addition to the rape.

Vetches. Hogs eat vetches even more readily than rape, but the vetches do not furnish so much food per acre. The vetches are ready for pasture a little earlier than the rape, and our common practice is to sow half our hog pasture with vetches, and half with rape. The sows are turned on the vetches first; and after this is eaten off, they are turned on the rape, and the vetch ground is sown with rape to furnish pasture late in the season.

Vetches may also be used as a soiling crop, as described under rape.

Hairy Vetch. The seed of this crop is very expensive. There is no doubt, however, that it makes an excellent pasture crop for swine. If not pastured too closely, it grows up quickly when the hogs are removed. For early spring pasture, it should be sown early in the fall, the latter part of August being a suitable time in most seasons. About 1½ bushels of seed per acre are required.

It is our intention to modify our arrangements regarding our hog pasture, and to sow about one-third of it with hairy vetch and rye in the fall; and in the spring, sow one-third with common vetches, and one-third with rape. The hogs will then go on the rye and hairy vetches early in the spring, then on the common vetches, and then on the rape. The common vetch ground will be sown with rape as soon as the hogs leave it; and the hairy vetches and rye will make a second growth while the hogs are eating the first plot of rape. By this means we hope to provide pasture earlier in the season than our present plan permits.

Red Clover. This crop is best suited for pasture; and the hogs should be given quite a large range, or the clover will likely be killed out. It is especially useful for breeding sows.

Alfalfa. Where the soil and other conditions are suitable, alfalfa makes an almost ideal pasture for swine. Care must be taken, however, not to pasture too closely, or the crop may be destroyed. On the college farm, where a short rotation is practised and only a small plot is set apart for a hog pasture, we think we get more satisfactory results from annual crops.

Soja Bean. This crop makes a valuable soiling crop for swine, but is not suitable for pasture. It has a high feeding value, and is much relished by swine. The crop is usually sown at the rate of half a bushel per acre in drills two feet apart. The medium green variety is quite satisfactory for this purpose. It is usually sown in the early part of May.

### Feeding and Management of the Boar.

The age at which a young boar may be first used, depends a great deal upon his development. Some boars will serve a few young sows when only six or seven months old, and apparently not be injured by it. As a rule, it is safer not to use a boar before he is eight months old, and to use him as sparingly as possible until he is a year old. No hard and fast rule can be laid down, and the owner must exercise his judgment in the matter.

The quarters for the boar should be roomy, and he should have an outdoor lot in which to take exercise. Some boars are extremely active, and will take plenty of exercise in a comparatively limited space. Some are very quiet and inclined to become too fat. It will be found beneficial with such a boar to force him to gather part of his living from pasture.

The boar should not be permitted to serve a sow more than once, and under no circumstances should he be allowed to run with the sows to which he is to be bred. This practice exhausts the boar, and is likely to result in small, weak litters. The best plan is to turn the sow into the boar's pen when she comes in heat, and to remove her immediately after she is served.

Boars frequently become lousy from serving lousy sows. Almost any of the standard sheep dips will kill lice if faithfully used. They should be mixed somewhat stronger than the directions call for. Coal oil is a very effective insecticide; but its tendency to blister the skin renders it objectionable. An excellent wash may be made as follows: Thoroughly mix 4 oz. of soft soap with 6 quarts of soft water; then add 8 oz. of naptha and mix again. This wash makes a good insecticide, and is also beneficial to the skin. The remarks on remedies for lice apply to all classes of pigs.

The food for the boar should be varied, nutritious, and moderately bulky. Succulent foods, such as roots in winter, and green food of some kind in summer, should always be fed with his meal ration. Succulent foods are necessary to keep him in good health. Finely ground oats are very suitable for the main part of his meal ration. An equal weight of middlings, or middlings and bran, added to the oats, makes a good combination. Small proportions of other kinds of meal may be added, if desired. He should be fed only what he will eat up clean; and if he is inclined to become fat and lazy, the food should be reduced.

### Feeding and Management of the Sow.

A sow should not be bred before she is eight months old, and in many cases it is better to delay breeding two or three months longer. The development of the sow will influence the breeder in this matter.

During the period of gestation, sows of all ages should have abundant exercise. In summer, pasture should be provided for them. The winter quarters may vary with conditions; but the matter of exercise should never be neglected. Where only a few sows are kept, they can frequently be given the run of the barnyard, where they will take exercise rooting over the manure. They should have dry, well bedded sleeping quarters, that are free from draughts. When it is impossible to use the barnyard, it is more difficult problem. Perhaps one of the best methods is to make use of the portable pens, described in another place. These should be placed at least fifty yards from the feeding troughs. The door should face the south, and the pen should be kept well bedded. If the pen is banked about the outside with horse manure, draughts will be excluded, and the pen will be comfortable and well ventilated. This plan forces the sows to take exercise in going to and from the troughs; and exercise is absolutely essential to the production of strong, healthy litters. A large number of sows can be run together in this way. Care should be taken to provide plenty of trough room; and the troughs should be located on high, dry ground, or a platform should be arranged on which to place them.

A record should be kept of the date of service of each sow, so that the date of farrowing will be known in advance. Sixteen weeks from date of service to date of farrowing, is a sufficiently close calculation. A week or ten days before she farrows, the sow should be placed in the farrowing pen, so as to become accustomed to her changed conditions before farrowing. She should still be encouraged to take a reasonable amount of exercise, however.

The pen should be provided with guard rails, made of 2 x 8-inch planks placed with the edges against the sides of the pen about ten inches from the floor. These prevent the sow from lying against the partition and lessen the danger of injury to the little pigs, which often find the space under the guard rail a very convenient refuge. A little cut straw or chaff makes the best bedding, as the little pigs are apt to become entangled in long straw, and find difficulty in keeping out of the way of the sow when she moves about. The sow should be handled, more or less, before she farrows, so that she may become accustomed to the presence of the attendant in the pen. A sow treated in this way, is less likely to become irritable and excited when the attendant enters the pen after she farrows. If everything goes well, she will require but little attention after farrowing, and the less she is interfered with, the better, except when it is absolutely necessary.

Many sows will take the boar a few days after farrowing. To breed a sow at such a time is a bad practice. No sow can do justice to herself and two litters of pigs at the same time. The sow usually comes in heat a few days after her pigs are weaned, and may then be bred again, if not too much pulled down by nursing. If she has raised a large litter and is very much emaciated, the chances are that she will produce a very small litter the next time, if she is bred immediately after her pigs are weaned. In such instances, she should be given three weeks or a month of liberal feeding to enable her to regain her lost strength and vitality before she is bred. Many a man has been puzzled to know why his sow, which had raised a fine, large litter, should drop down to only four or five puny pigs the next time. The reason is not far to seek. To produce a large, vigorous litter, the sow must be strong and full of vitality at the time of service.

In feeding the breeding sow during the period of gestation, the feeder should aim to keep her in good, strong condition, without having her become extremely fat. Many go to the other extreme, and keep their sows thin; and the thin sow either will not do justice to her pigs, or will become a mere wreck herself during the time she is nursing her litter—in fact, the chances are that both these things will happen. A sow may be kept in pretty high condition and still produce satisfactorily, provided she takes plenty of exercise.

When on good pasture, particularly clover pasture, sows require very little meal. As a rule, however, it is well to give them a light ration of ground oats and bran or middlings. It is well to avoid the heavier and more heating kinds of grain. If used at all, they should be used very sparingly. In winter, roots should take the place of the green food; and when the sows are fed outdoors as recommended, it is best to feed the meal dry. They will require little water outside of that supplied by the roots, during cold weather. In cold weather, a little corn, wheat, or rye may be added to the oats and bran ration when the sows are fed outside, as they can stand rather more heating food under these conditions. It is, perhaps, just as well to omit barley from the ration of a breeding sow.

When the sow goes into the warm farrowing pen, it is advisable to feed the meal in the form of a thick slop, and a moderate ration of roots should be continued. This system tends to prevent constipation, and a more or less fevered condition, which may result from changing from outdoor life to confinement. After she farrows, there should be no hurry about feeding her. If she lies quiet for ten or twelve hours, so much the better. At first, she should have little more than a drink. A very thin slop of bran and middlings, given in small quantities, will answer very well. The food may be gradually increased, and in the course of a week or ten days she will be on full feed. A good mother with a large litter requires very liberal feeding. If the litter is small, it may be necessary to reduce the quantity of food.

Many different rations are used for nursing sows. A very good ration can be made by mixing two parts of finely ground oats with one part of bran and one part of wheat middlings, and allowing the food to soak between feeds. A few roots should also be fed. Sweet skim-milk is good. Some feed a small quantity of oil cake, and no doubt it is beneficial in the mixture. The heavier grains should be fed very sparingly, if at all; and barley should be omitted, as it is not a good milk former.

After the pigs are weaned, the food should be cut down to check the secretion of milk. Dry oats are a safe food for a few days after the pigs are taken away. If the udder gets very full, it is a good plan to turn the sow in with the pigs once a day for a few days.

### Feeding and Management of Young Pigs.

When the little pigs are born, the attendant should be on hand and see that they are placed on their mother to suck as soon as possible. Some prefer to put the pigs in a box or basket, for the first day or two, taking them out at short intervals to suck. If the pigs are strong, however, and the sow is a reasonably good mother, it is better to leave them with her.

By the time the pigs are three weeks old, they will have learned to eat. If at all possible, they should be given access to another pen, in which is kept a small trough. Here they can be fed a little skim-milk, with a very little middlings stirred into it. The quantity of middlings can be gradually increased as the pigs grow older. If they can be taught to nibble at roots during this time, all the better. A little whole wheat, or soaked corn, scattered on the floor of the feeding pen, will cause them to take exercise while hunting for it. Exercise is very important for young pigs; and every possible means of securing it, should be adopted. If they are kept in a small pen with the mother, some of the best of them are apt to become too fat, and are likely to sicken and die. Pigs that come in the spring, however, or early fall, are more easily managed than winter litters, as they can be given outdoor exercise. If the sow is turned out with her pigs, it is not well to give her a large range, as she is likely to travel too far and tire the pigs too much.

The pigs may be weaned at six weeks old. If skim-milk is not available, it is generally better to defer weaning until eight weeks old. If they have been taught to eat as described, they will go right on eating and suffer but little from weaning. Skim-milk and middlings make about the best food for young pigs at this time. The middlings should be soaked a few hours before feeding, or, better still, scalded. If fed freshly mixed, they are likely to cause indigestion. A few finely ground oats with the hulls sifted out, make a good combination with middlings. When the pigs are first weaned, it is better to feed four times a day, feeding only what they will eat up clean before leaving the trough. When well started, they may be changed to three feeds a day.

When the pigs are three months old, a little ground barley may be added to the meal mixture. At first, the barley should constitute not more than a fifth of the total ration; and it can be gradually increased as desired, or other foods added as indicated under notes on foodstuffs.

It is important to teach young pigs to eat a few roots as early as possible; or, if it is too late in the spring for roots, some form of green food should be supplied every day.

## PART V.—MISCELLANEOUS.

Cooking Food for Swine. A great many experiments have been conducted with cooked food for swine at the various experiment stations; and for this reason we have done practically nothing in this line of work, with the exception of cooking turnips. Taking the results of tests from different stations, we find many contradictory results, sometimes the cooked food scoring an advantage, but oftener, the uncooked taking the lead. So far as can be made out from the results, it would seem that cooking does not increase the feeding value of meal; and the weight of evidence is in favor of the theory that cooking decreases the digestibility of meal. Potatoes, however, appear to be improved by cooking. Turnips are rendered more palatable by cooking; but it is doubtful whether their feeding value is increased thereby. If it is desired to feed a large quantity of turnips, no doubt cooking is an advantage. In the case of sugar beets and mangels, which the hogs eat readily in the raw state, it is very doubtful whether cooking pays. On the whole, therefore, cooking apparently tends to make foods more palatable in some cases; but its effect upon the digestibility of foods appears to be injurious, rather than beneficial. Potatoes, however, seem to be an exception to the general rule, and are believed to be more digestible, as well as more palatable, when cooked.

Soaked, Wet and Dry Meal. So far as can be gleaned from experiments to date, soaking meal for several hours before feeding appears to improve its feeding value. It is doubtful, however, whether wetting the food just before feeding has very much influence. One of the difficulties we have experienced in feeding dry meal, is the prevention of waste, particularly in outside feeding, where a rather large number of hogs are fed together. In such cases, considerable meal is thrown out of the troughs and trampled into the earth. Where only a few hogs are fed together, especially where they are fed in a pen with a cement floor, there is very little waste. Where the meal is fed wet, there is danger of forcing a hog to take more water than it requires, especially in cold weather. This is most important in the case of breeding sows, especially where they are fed outdoors, as recommended elsewhere. For breeding sows fed outdoors, we would recommend dry meal. There may be a waste of meal, but we believe this will be more than paid back when the pigs are born. The whole matter, after all, is largely one of judgment, and calls for careful study of the conditions under which the feeding is done. For ordinary winter feeding, we have had very satisfactory results from mixing the dry meal with pulped roots, and allowing the mixture to stand from one feeding time to another. Both roots and meal seem to be made more palatable in this way. In warm weather, there is much less danger of supplying more water than is required.

Relation of Live Weight to Economy of Gain. In various experiments it has been shown that the amount of meal required for a pound of gain in weight steadily increases as the pig becomes heavier. Our experiments with pure-bred swine bring out this point very clearly, as the following statement shows:

| Live weight of hogs. | Meal required for 100 lbs. increase in weight. |
|---|---|
| lbs. | lbs. |
| 54 to 82 | 310 |
| 82 to 115 | 375 |
| 115 to 148 | 438 |
| 148 to 170 | 455 |

Prof. W. A. Henry, in his book "Feeds and Feeding," gives a very interesting table under this head, which he compiled from the results of many experiment stations. This table indicates that hogs weighing from 150 to 200 pounds require 482 pounds meal for 100 pounds gain; from 200 to 250 pounds, 498 pounds meal; and from 250 to 300 pounds, 511 pounds meal. It will be seen from these figures that the weight at which the Canadian packer wants the hog, is just about the limit of profitable feeding.

Correctives. Swine appears to have a craving for what might be called unnatural substances. This is especially true of hogs that are kept in confinement, which will eat greedily such substances as charcoal, ashes, mortar, soft coal, rotten wood, etc. It is probable that some of these substances are not good for hogs; but there is no doubt that charcoal and wood ashes have a beneficial effect, the former being greatly relished. It is good practice to supply charcoal, especially during the winter months. Wood ashes, or a mixture of wood ashes and salt, may be used in place of charcoal; but charcoal is preferable. Sods make a very fair substitute for charcoal. A waggon load or two of sods placed conveniently near the piggery, so that the feeder can throw one or two into each pen occasionally, will be found well worth the labor involved. Pigs that are outdoors in summer, and have access to earth and vegetable matter, have little need of other correctives. The term "correctives" is used for want of a better; but such substances as those described, appear to correct, or to prevent, derangement of the digestive organs.

The Feeder. To make a successful feeder, a man must have a love for the animals under his charge, and be willing to sacrifice his own comfort and convenience to theirs. He must possess sound judgment, and must make a study of the animals under his care, so that he will be able to detect the first signs of anything wrong. He must have a knowledge of the foods suited to different ages, sexes, and conditions, and his judgment will be shown in using these foods to secure the best results. In spite of all directions which may be given, emergencies are always arising to test the judgment and resourcefulness of the feeder. The suggestions, therfore, which have been offered in this bulletin, are intended as a general guide, but they cannot supply the place of skill and judgment on the part of the feeder.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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# ONTARIO AGRICULTURAL COLLEGE

## BULLETIN 130.

# A COMPARISON OF THE BACTERIAL CONTENT OF CHEESE CURED AT DIFFERENT TEMPERATURES.

BY

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Ontario Agricultural College and Experimental Farm.

# A COMPARISON OF THE BACTERIAL CONTENT OF CHEESE CURED AT DIFFERENT TEMPERATURES.

By Prof. F. C. Harrison and Prof. W. T. Connell.

The following investigations were made partly at the Agricultural College, Guelph, and partly at the Eastern Dairy School, Kingston, the latter being done under the direction of the Commissioner of Agriculture and Dairying for the Dominion. The object was to determine the bacteriological conditions existing in Canadian Cheddar cheese when cured at different temperatures; to note the relationship existing between the bacterial contents and other curing agencies; and to learn, if possible, some lessons of practical value for those engaged in the production of cheese.

## Sources of Cheese Analysed.

The cheese subjected to analysis were of two distinct groups. The first group consisted of those made and kept at the factory at Carp, Ontario, during the seasons of 1899 and 1900. This lot comprised 28 cheese in all, 14 being analysed in 1899 and 14 in 1900, each cheese being examined a number of times at various intervals. One-half the cheese examined each season was kept in an insulated curing room at a temperature varying between 60 and 65 degrees Fah., the average for both summers being 62.2 degrees Fah., the maximum recorded being 67 degrees and the minimum 56 degrees. The remaining half was kept in an ordinary curing room in which no attempt was made to control the temperature. The average temperature of this room in 1899, while containing the cheese analyzed, was as follows: Last fifteen days of June, 68.7 degrees Fah.; July, 70.5 degrees Fah.; August, 70.8 degrees Fah. The average temperature of this room in 1900 was: July, 72 degrees Fah.; August, 69 degrees Fah.

The temperature of the insulated room, which was isolated from the ordinary curing room, was regulated by a sub-earth duct and by the use of ice in racks. Full details as to methods of structure and insulation of the ordinary curing room and factory are given in the reports of the Commissioner of Agriculture and Dairying for 1899.

The second group of cheese consisted of those made at the Agricultural College factory, Guelph. The work in this group related to the effects of ripening cheese at a temperature of about 40 degrees Fah. throughout the whole period of curing, and ripening for one and two and three weeks in an ordinary curing room, and then removing to cold storage—both compared with ripening for the full period in the ordinary curing room.

In these experiments five flat Cheddar cheese were made from each curd, and were marked A, B, C, D and E. The cheese were put directly into ice cold storage, where the temperature averaged 37.8 degrees Fah., and the percentage of humidity averaged 91.6 degrees for the season. The extreme variation in the monthly average temperature of the cold storage from April to November was 4 degrees; and the variation in the humidity was 4 degrees.

The other five cheese were put into the ripening room, and transfers were subsequently made from the ripening room to cold storage, as follows: The B cheese at the end of one week; the C cheese at the end of two weeks; and the D cheese at the end of three weeks. The E cheese were left in the ripening room and ripened in the ordinary way at an average temperature of 63.8 degrees Fah. for the season. The average percentage of humidity in this room was 79.1 degrees for the season. The average monthly variations in the temperature of this room were from 86.6 degrees in July to 58.7 degrees in November. The humidity varied from 84.3 per cent. in August to 73.7 per cent. in October. The temperature of the air outside averaged 56.9 degrees for the season. The average maximum temperature outside ranged from 85.8 degrees Fah. in July to 39 degrees in November.

The average minimum outside temperature ranged from 59.6 degrees in July to 24 degrees in November. The month of July was the hottest month of the season, and August was next, with maximum and minimum averages of 79.7 degrees and 56.3 degrees. June averaged 77.4 degrees and 53.5 degrees for maximum and minimum temperatures.

It should be remembered that it is not strictly accurate to take the average temperature by adding together the maximum and minimum temperatures and dividing for the average, as there is often a large variation in temperature, and the temperature for the day would, as a rule, more nearly approximate the maximum figure for a longer period of the day than the average.

### Taking of Samples.

Samples from the Carp factory were taken by Mr. Woodard, the maker, under the direction of one of us. Samples were always taken of cheese of the same day's make, kept in the regulated and variable rooms, so as to have a contrast between cheeses of the same age. The samples analyzed and compared were always taken from cheese of the same day's make. The samples were taken with a thoroughly cleansed cheese borer and immediately placed with great care in sterilized test tubes, always two of each cheese, in order to have a duplicate in case any accident should befall one of the samples. The cheese borer was cleansed before using to obtain the second specimen; and the test tubes were plugged, packed on ice and forwarded to Kingston, being received about eighteen hours after they were taken.

At this point the analyses might not be entirely reliable; for while specimens usually came in good condition, still on several occasions, the ice in the packing box was completely melted, and the contents of the box were almost at the temperature of the air—which was likely due to the placing of the box in some exposed place by the carriers. The exact effects of such a change in temperature could not be accurately gauged; but when it was considered to be a factor, the results of the analysis were excluded from the tables.

The samples of cheese taken from the College factory, Guelph, were obtained in a similar way, except that it was not necessary to pack them on ice, as the laboratory is only a few minutes' walk from the factory. These samples were promptly taken from the factory to the laboratory and immediately analyzed.

A source of error in the quantitative bacteriological analysis of cheese is the fact, repeatedly determined in control analyses, that plugs from different parts of the same cheese, of the same age, vary as much as 30 per cent. in their bacterial content. Further, even in the same plug, portions of equal weight sometimes show as high as 20 per cent. of difference in the number of bacteria contained in them. A few examples of this fact may be given. A plug from cheese of July, 1902, age 12 days, gave 144,000,000 per gram. From cheese made in September, 1902, the age being 40 days, one plug gave 27,000,000 per gram; and another from a different part of the cheese gave 22,500,000 per gram. From cheese of July, 1902, age 12 days, the upper portion of a plug gave 210,000,000 per gram and lower portions of the same plug gave 293,000,000.

We have also noticed in abnormal cheese, made by adding a culture of a gas-producing germ to the milk, that in the separate particles of curd which unite to make the cheese, the exterior surface of each particle contains a larger number of bacteria than the interior thereof. Thus, in an analysis of cheese made in November, the exterior, or outer surface, of the curd particles gave 456 millions per gram, while the interior thereof gave 51 millions per gram; and again, at a later date, the exterior and interior of the curd particles in the same cheese gave respectively 67 millions and 37 millions per gram.

These examinations, which are typical of many others which we have made, show that there is not an even distribution of bacteria throughout the substance of a cheese, and it would, therefore, seem necessary to modify somewhat our methods of analyses.

## Methods of Analysis, Etc.

Methods followed in the Analysis of Samples. The samples sent from Carp factory to Kingston were all subjected to an examination by the different methods of culture. Control microscopic examinations of the cheese were frequently made to determine if there were in them any forms which did not develop in the culture plates. No forms were found, however, except those which developed in the cultures.

The medium used for the culture of the bacteria contained in the cheese from the Carp factory was the ordinary beef-peptone-gelatine (12 per cent.). Agar proved entirely unsuitable for the requirements of the investigation. The cultures were made aerobically, the few cultures made anaerobically not showing the development of any forms except those found in the ordinary plates.

The medium used for the Guelph cheese was peptone-whey gelatine (10 per cent.), with or without the addition of blue litmus, precipitated chalk, or rosolic acid. Usually two plates were made from beef-peptone lactose gelatine. For each sample, from 5 to 7 plates were made.

## Kingston Method.

As the methods followed at Kingston were somewhat different from those used at Guelph, we shall briefly outline them.

The Kingston Method. Usually one-tenth gram of the interior of the plug was taken and thoroughly pulverized in a sterile mortar with coarse granulated sugar. The sugar had been previously sterilized by soaking under ether for 2 to 7 days and then carefully evaporating the ether.

The finely pulverized mass was then washed with a measured amount of sterile water into a sterilized shaking bottle, and this was kept constantly agitated so as to secure a thorough and even admixture. The amount of dilution required varied with the age of the cheese. It was found that for green cheese a dilution of one part of cheese in from 20,000 to 100,000 parts of sterile water was required. This dilution was commonly effected as follows: 100 cc. of water were used to dissolve the powder and wash it into the first sterile shaking bottle. After this bottle had been thoroughly agitated for at least three minutes, 5 cc. were quickly removed with a sterile pipette and added to a second shaking bottle. To this was then added as many cc.'s as would make the dilution required. By this means one avoided the use of a large amount of diluting fluid. From the second bottle, after prolonged agitation, measured quantities were quickly added to melted gelatine. After a careful admixture with the gelatine culture was secured, plates were poured in the usual manner. These plates were incubated at from 21 to 22 degrees C., till all development had ceased. The colonies which had developed were then carefully counted over the entire surface of the culture plates, and the various colonies identified as to their species. Repeated sub-cultures in various media had often to be made to establish the identity of a species; but this work was rendered somewhat easier by the marked predominance of the bacillus acidi lactici.

## Guelph Methods.

The Guelph Methods. One-half or one gram of cheese was taken and pulverized in a sterile mortar, with ten grams of powdered glass thoroughly sterilized; and 50 cc. of sterilized warm water (37 degrees C.) was gradually added, with constant stirring, to make a fine emulsion. And we think that by taking cheese in considerable quantity from different parts of the interior of the plug and pulverizing the samples with sterilized powdered glass, using ten grams of powdered glass for each gram of cheese, more accurate results were obtained than could be secured by the methods followed in former investigations. When these larger amounts of cheese were used, the quantity of the diluting fluid had to be considerably increased, and the labor of preparing the samples was much greater; but undoubtedly the results obtained were more accurate and gave a more reliable estimate of the bacterial content of the cheese For the larger number of the Guelph analyses, one gram of cheese was used. In a few instances five grams were used.

From the first dilution, one or two cc. were transferred to a measured amount of sterile water in a sterilized flask. After thorough shaking, a measured quantity was again transferred to a measured amount of sterile water in another sterilized flask; and, after further shaking, various quantities of this third dilution were added to the culture media. For transferring portions of the mixture from one dilution to another, straight-sided (Mohr) pipettes were used, and great care was taken to keep the liquid in the pipette in motion; for if not kept in motion, the particles in suspension would settle in a short time at the bottom of the pipette and thus interfere with the accuracy of the results. The amount of dilution varied with the age of the cheese from 750,000 to 100,000 parts of sterile water to one part of cheese. The plates were levelled on a nivellating apparatus, cooled with ice, and subsequently placed in a cool incubator at 20 degrees C., where they remained till all development had ceased. The colonies were counted by means of a Jeffers counter; and computations were made therefrom.

De Freudenreich's method of obtaining liquefying germs by making surface cultures from the last dilution was occasionally used.

As previous work upon the bacterial flora of cheese had failed to show any obligate anaerobes, no anaerobic methods of culture were used.

## Bacteria Found.

The bacteria found in the cheese at Guelph are divided into four classes:

A. True Lactic Acid Bacteria, of which several varieties differing only in slight particulars were found. All were bacilli, usually arranged as diplo-bacilli, at times in short chains. The commonest species was undoubtedly the B. acidi lactici (Esten).

B. Gas-forming Bacteria. These were mainly varieties of the B. coli communis and the B. lactis aerogenes, although once or twice a species which in most particulars resembled Proteus vulgaris was isolated.

C. Indifferent Bacteria. Various sarcinae, particularly Sarcina lutea, some yeasts, and torlae were found. B. subtilis and one or two other casein digestors were isolated; but their action, on account of their small numbers, must be considered insignificant. Further, none of these latter species was constantly present; so their action may be regarded as having little or no influence in the curing of the cheese.

In this class one of us included all bacteria, not lactic acid or gas-producing.

D. Digesting Bacteria. By means of surface gelatine plates and emulsions of cheese, heated in order to destroy all vegetative forms and thus leave only spore-producing species, constant endeavor was made to isolate organisms belonging to this class.

In former analyses of cheddar cheese, one of us found seven different species of digesting or liquefying germs, the commonest form being B. butyricus. In this investigation, liquefying bacteria belonging to the subtilis group, M. aureus lactis, M. varians lactis, B. fulvus and B. halofaciens were isolated. Most of these species are liquefying, chromogenic forms. According to Conn, the second named is a distinctive dairy type which he found very frequently in milk. We may add that it has been isolated from the milk-ducts; and, in this connection, may note Harding's opinion, that the enzymes from liquefying bacteria, isolated from the udder of cows, may have some influence in the ripening changes of cheddar cheese. However, as already pointed out, none of these species are constantly present in cheese. Hence their action must be insignificant.

As may be seen from the appended tables, the lactic acid bacteria were the only constant bacteria present in vary large numbers.

### Commercial Opinions on the Kingston Cheese.

Commercial Opinions on the Kingston Cheese. Commercial examinations of the same batches as those analysed were made at different dates. Part of the cheese was examined in Montreal in November, 1899, where the cheese had been held in cold storage from the early part of September. Cheese from the non-regulated room, made on and after the 29th of July, were destroyed by fire on the way to Montreal; so no comparison can be made between the cheese of these days' make kept in regulated and in non-regulated curing rooms.

COMMENTS OF THE JUDGES UPON KINGSTON CHEESE MADE IN 1899:

| †Date. | Cheese in regulated room. | Cheese in non-regulated room. |
|---|---|---|
| June 22 | Body texture and flavor better. | Tender; on verge of going off. |
| July 1 | Better body and flavor and more waxy. | Not clean. |
| July 7 | Nearly alike; rather better body, and slightly better cheese. | Hardly clean; tender. |
| July 13 | Clean; waxy. | Not quite clean; body tender. |
| July 19 | Good cheese. | Pasty; not clean. |
| July 29 | Off flavor. | Not reported owing to destruction in transit. |
| August 10 | Good flavor. | |

†For the bacterial data of these cheese, please refer to the same dates in the tables of analysis commencing on page 14.

COMMERCIAL RATINGS OF THE KINGSTON CHEESE MADE IN 1900.*

| Date. | Room.‡ | Vat. | Body. In Order of Merit. | Flavor. In Order of Merit. | Remarks. |
|---|---|---|---|---|---|
| †July 7.... | 1 | ........ | .......... | 1 | Best cheese of entire lot. |
| " 6.... | 1 | ........ | .......... | 2 | Slightly fruity. |
| " 5.... | 1 | ........ | .......... | 3 | Off flavor. |
| " 7.... | 2 | ........ | .......... | 4 | Tallowy. |
| " 6.... | 2 | ........ | .......... | 5 | Fruity flavor. |
| " 5.... | 2 | ........ | .......... | 6 | Off flavor. |
| " 19... | 1 | 1 | 1 | 1 | Body about alike in all cheese in room 1. |
| " 19 ... | 1 | 3 | 2 | 2 | Off flavor. |
| " 19.... | 2 | 1 | 3 | 3 | Cheese from vat 3, room 2, contained slightly more moisture than cheese from vat 1, room 2. |
| " 19.... | 2 | 3 | 4 | 4 | |
| " 18.... | 1 | 1 | 1 | 1 | Less moisture; better flavor than other cheese of this date. |
| " 18 .. | 1 | 3 | 2 | 2 | Off flavor; more moisture than in other cheese of this date. |
| " 18.... | 2 | 1 | 3 | 3 | |
| " 18.... | 2 | 3 | 4 | 4 | Poorest of lot. Cheese of July 19th equal to that of July 6th in flavor. |

* These cheese were not scored according to any scale.
† For the bacteriological data of these cheese, please refer to the same dates in the tables of analysis commencing on page 14.
‡ No. 1 is the regulated room and No. 2, the non-regulated room.

## Scorings of the Guelph Cheese.

Quality of the Guelph Cheese. These cheese were scored according to the following scale of points: Flavor, 40; closeness, 15; even color, 15; texture, 20; finish, 10; total, 100. They were all scored 10 points for finish, in order to make the results more uniform. Six prominent cheese buyers of Montreal and four Ontario buyers did the scoring; and the following table shows the average of all the scorings made by months:

| † | Flavor. Max. 40 Av. | Closeness. Max. 15. Av. | Even color. Max. 15. Av. | Texture. Max. 20. Av. | Total. Max. 100. Av. |
|---|---|---|---|---|---|
| April cheese. | | | | | |
| A | 35.7 | 14.7 | 14.2 | 17.6 | 92.3 |
| B | 35.5 | 14.6 | 14.1 | 17.4 | 91.5 |
| C | 34.5 | 14.7 | 14.1 | 17.4 | 90.7 |
| D | 35.8 | 14.3 | 14.1 | 17.7 | 91.9 |
| E | 25.6 | 14.1 | 11.5 | 15.5 | 76.7 |
| May cheese. | | | | | |
| A | 36.1 | 14.7 | 14.1 | 17.9 | 92.9 |
| B | 35.9 | 14.4 | 13.7 | 17.8 | 91.8 |
| C | 35.4 | 14.5 | 13.8 | 17.5 | 91.2 |
| D | 35.8 | 14.4 | 13.8 | 16.9 | 90.9 |
| E | 33.9 | 13.9 | 13.9 | 16.2 | 87.9 |
| June cheese. | | | | | |
| A | 33.5 | 14.8 | 14.5 | 17.4 | 90.2 |
| E | 31.6 | 14.1 | 14.0 | 15.2 | 84.9 |

†For the bacterial data of these cheese, please refer to the same dates in the tables of analysis commencing on page 14.

The first scoring of the cold-storage cheese (A, B, C and D in the table) was made when they were from three to four months old; and they were scored several times thereafter. The cheese ripened in the ordinary room (E in the table) were scored the first time when they were from six weeks to two months old, and again at intervals of about one month after the first scoring, until it was considered that there would be no advantage in keeping them for a longer time.

## Remarks on the Analytical Results.

A study of the tables of analysis (page 14 to end) shows that each day's cheese differs in its quantitative bacterial content from the cheese of every other day's make. This is not to be wondered at, when we remember that each day's milk differs more or less from that of every other day, and that little differences in handling are of daily occurrence. Such differences in the milk, in the handling of the curd, and in the use of various temperatures, no doubt account for the differences in bacterial content. A perusal of the tables shows a very great difference in the initial number of the bacteria in cheese. The lowest number found in cheese under four days old was 110,750,000 per gram; and the highest number in cheese of the same age was 635,000,000 per gram.

It may also be noted that the bacterial content declines more rapidly in the cheese of some day's make than it does in others. This may also be due to different conditions, such as those already mentioned, and to the influence of the products of bacterial activity upon the living organisms.

The tables also show that the bacterial content of normal cheese is usually at its highest at the time of taking from the press or during the first few days after the cheese are placed in the curing room. In other words, the bacteria in cheese are the survivors of bacteria in the curd. This statement, however, does not always hold good; for we may have cheese in which the acidity has not developed to such an extent as is usually considered desirable; and in such a case there will likely be a period of bacterial development after the cheese is placed in the curing room. It has also been claimed that there is more likely to be bacterial development when the cheese are moister than usual; but, in our investigations, no difference was observed in the quantitative analysis of cheese coming from "moist" and from "ordinary" vats.

By the experimental data given here, the number of bacteria was shown to be at its maximum when the cheese were taken from the press; and following this period we had (taking into account the factors leading to error in analysis) a continuous and gradual decline in the bacterial content. This decline continued till about the 100th day, when the contents seemed to remain fairly stationary for some time. Following this period, in which the bacterial content remained at a fairly constant level, we had a gradual decline; but in some cheese a year old, from 10,000 to 500,000 lactic acid bacteria were found.

The decline was more gradual and the contents remained high for a longer period in the cheese kept in ice cold storage at an average temperature of 40 degrees than in cheese kept in an ordinary curing room. This statement, but in a lesser degree, is also true of cheese kept in cool or regulated rooms. Without exception, we found a higher bacterial content in the cheese kept in the ice cold storage and in the regulated room,.and also noted that there was better body and flavor in the cheese from these rooms, than in those from the unregulated curing rooms. This factor of higher bacterial content must, therefore, be one of considerable importance, particularly as regards the flavor of the cheese. The proportion of lactic acid bacteria to undesirable organisms is much greater in cold-storage and cool-storage cheese than is usual under ordinary conditions; and this ratio remains constant for a greater length of time in the refrigerator cheese than in either of the others; and it is obvious that a cheese with the ratio of 97 lactic acid bacteria to one undesirable organism will be of better flavor than a cheese kept in an unregulated curing room with a ratio of 47 lactic acid bacteria to one undesirable one. These ratios are in some of the cases, given in the tables of analysis.

The lactic acid bacteria are practically the only organisms present in normal cheese, and certainly the only bacteria in each particle of it; so it must be the only microbe of much importance in good cheese. It is true that gas-forming bacteria and other undesirable kinds were found in nearly every cheese we examined; but they were usually present in the samples taken at an early date, and very exceptionally in those of later date. They seldom, if ever, increase in numbers.

The presence of the proteus form in the cheese of July 29th, even though it did not increase in numbers, likely accounts for the cheese of that day going "off" in flavor. Such forms are favored by the warmer temperature of the variable room; but the large numbers of the lactic acid bacteria prevent their growth and soon destroy most of them. Gas-forming bacteria do multiply and are found in large numbers in open cheese, and especially in cheese in which this taint develops early. This may be due partly to a lack of acid in the cheese, and partly to various other defects in the manufacture. Both B. Coli and B. lactis aerogenes produce mottling. Conclusive evidence of this fact was obtained from a number of our experiments, made by using starters of these gas-producing organisms and manufacturing cheese therefrom. The mottles were most marked at the places where the particles of curd came together; holes and cracks also developed at these places, and it was evident that the gas produced by these organisms, particularly the hydrogen, had a marked bleaching action upon the curd. We also found that the white particles produced by bleaching contained much larger numbers of the gas-producing organism than other portions of the cheese.

The results of more detailed experiments upon this phase of the question will be given in a subsequent publication.

The lactic acid bacteria decline most rapidly in cheese kept in a room with a variable temperature; and when such decline takes place, any other bacterial species present is likely to multiply and produce its characteristic effects. This, perhaps, accounts for cheese going "off" in flavor when they become quite old; and such an undesirable result is much more likely to occur in cheese from a room of variable temperature than from cool or cold rooms, regulated by any of the methods adopted for the purpose. It may also be possible that abnormal flavors are produced by organisms which can grow only after a certain decomposition effected by a previous organism, the first furnishing a suitable food for the second. We do not yet know whether lactic acid bacteria render cheese suitable or unsuitable for the growth of any other species. The neutralization of the lime salts of the cheese by the generated lactic acid may at times bring about a condition suitable for the development of other bacteria which may be present in a dormant condition. The metabiotic phenomena in cheese certainly require further study.

As cheese become older, the lactic acid bacteria gradually lose their power of producing lactic acid when introduced into fresh milk. No morphological change can be detected in these bacteria. Colony formation on culture media remain quite characteristic. Lloyd has obtained similar results. He, however, thinks that lactic acid formation still goes on in the centre of the cheese; but, in our opinion, these bacteria are simply persisting forms of the contained bacteria. Reference to the tables shows that, on several occasions, we had an apparent increase of bacteria in cheese, several weeks old, kept at a temperature of 40 degrees Fah.; and we explain these results as due to the unequal distribution of bacteria in the cheese; for, by a number of experiments, we proved that there could be no increase of the lactic acid bacteria in milk kept at 40 degrees Fah. Some of the experiments on this point may be referred to.

On the 26th of November, 1902, 80 cc. of sterilized milk were inoculated with 2 oese of a 24-hour old bouillon culture of the lactic acid bacillus; and plates made from this mixture gave 430 colonies per oese. On the 3rd of December, this milk, at a temperature of 40 degrees Fah., was again examined and showed 150 colonies per oese; and at the same time, one drop of the milk was diluted in 12 cc. of sterilized water and two colonies per cc. of this mixture developed. On the 16th of December, the temperature being the same, 42 colonies per cc. and 2 colonies per oese respectively developed. The milk was then transferred to the incubator at 20 degrees C., and coagulated in 24 hours. Other experiments with gas-producing germs had similar results—there was no increase in the number of bacteria held at 40 degrees Fah. This experiment was repeated with lactic acid bacteria and gas-producing bacteria, with similar results, viz., that there was no increase in the numbers of bacteria in milk held at 40 degrees Fah. Consequently, there could be no increase in the number of lactic acid and gas-producing bacteria in cheese held at this temperature.

## Bacterial Contents and Ripening Phenomena.

Bacterial Contents and Ripening Phenomena. The question of the really active agent or agents in the curing of cheese is still an open one. If bacteria are the active agents, then lactic acid bacteria must be the agents in the process. De Freudenreich appears to have shown that these bacteria can produce an increase of the soluble nitrogenous products in the casein of milk, provided calcium carbonate is present. Klein and Kirsten stated that, by the use of starters, normal cheese can be made from pasteurized milk (which is free from enzymes); but Boekhout and Vries were unable to produce normal Edam cheese from aseptic milk with the addition of a culture of the lactic acid bacillus; and Chodat and Bang did not obtain an increase in the quantity of soluble nitrogen by growing lactic acid bacteria on coagulated casein; so, taking these facts into account, we are bound to admit that there still exists more or less doubt as to the ability of the lactic acid bacillus alone to produce an increase in the amount of soluble nitrogen.

Babcock and Russell attributed to Galactase (an enzyme which they discovered in milk) the principal influence in the ripening of cheese; but De Freudenreich has shown that 0.5 per cent. of lactic acid enfeebles the action of galactase; and the very considerable amount of acid in normal Canadian cheddar cheese must still more diminish the action of this ferment, as the percentage of acidity or acid salts in ordinary cheese of this kind varies at different ages from 0.76 per cent. to 1.5 per cent.

Babcock and Russell (subsequent to the discovery of Galactase) and Jensen simultaneously proved that the pepsin in rennet increased the higher decomposition products, such as albumoses and peptones, in cheese; and there is the well-known fact that cheese-makers increase the amount of rennet when they want a fast-curing cheese.

Rennet acts more quickly and better than galactase in acid solutions; and it seems that the function of the lactic acid bacteria, whose growth in milk is so carefully fostered by the cheese-maker, is to create the requisite acidity in order that the pepsin of the rennet may exercise its digestive action on the cheese; and it appears certain that the fundamental curing changes commence during the maturing of the curd in the vat, but do not make themselves manifest till later.

### Production of Flavor.

Production of Flavor. The most important characteristic of cheese is its flavor. Buyers of cheddar cheese, especially, judge very largely by the flavor; and no other characteristic counts for so much in estimating the market value. It is, therefore, necessary that the factors which contribute to the production of flavor should be thoroughly understood.

B. coli, B. lactis aerogenes, Proteus, etc., are sometimes present in milk and cheese, and are to be guarded against, on account of the abnormal flavors which they produce; and other species are occasionally found, but in such small numbers that they produce little or no effect upon the flavor of the cheese; but from the analyses here presented, it is evident that the lactic acid bacillus is the only species of organism which is of much importance to cheese-makers. Generally speaking, the flavor of the cheese depends mainly upon this organism, when it is present in large numbers, and in what we ordinarily term pure culture, we get the best flavor. It is only when the cheese breaks down under the influence of the enzymes in the rennet, after the ground has been prepared by the lactic acid bacteria, that flavor develops. The rapidity and character of the ripening process, involving the life of the lactic acid bacteria, largely depend upon the temperature at which the cheese is kept; and the most important factor in the control of temperature is a well-regulated cold or cool room.

The quality of the cheese in the Guelph experiments was in the order of placing in cold storage as regards time—that put in directly from the hoops being the best. In the Kingston experiments, the cheese in the regulated room was superior to that in the ordinary non-regulated room; and in all these best cheese, the most noticeable fact was the high number of lactic acid bacteria which they contained and the length of time these organisms remained alive in them.

The similarity of germ content in the same kind of cheese, though made in various localities, has a bearing on the question; and we have found that in normal cheese from various parts of the Province, the lactic acid bacillus is the only species that is constantly found in large numbers.

### Conclusions.

1. The presence of certain undesirable bacteria sometimes produces "off" flavors in cheese. The Proteus form found in the cheese of July 29th was likely the cause of the cheese of that date being abnormal in flavor.

2. In nearly all the cheese examined, gas-producing, digesting or indifferent species of bacteria were found; but they always were in insignificant numbers and soon died out.

3. Undesirable bacteria such as are found in cheese seem unable to grow at a temperature of 40 degrees Fah. Consequently, the flavors in cheese caused by the growth of bacteria therein do not increase in cold storage.

4. In normal cheese, the greatest bacterial content is usually found when it is one day old, though occasionally it is at the maximum in cheese from two to five days old. At this period the number of bacteria sometimes reaches the enormous total of 625,000,000 per gram.

5. Following this period, we have a gradual and continuous decline in the number of bacteria as the cheese get older.

6. The bacterial content remains high for the longest time, and the decline is most gradual, in cheese kept in ice cold storage, at an average temperature of 40 degrees Fahrenheit. In cheese kept in a cool, well-regulated room, similar results occur, but the decline in the number of bacteria is more rapid. As this higher bacterial content constantly corresponds with a better flavor in the cheese, we infer that it is the chief factor in determining the flavor of cheese properly made from good, pure milk.

7. Lactic acid bacilli are practically the only bacteria in normal cheese during the ripening process; and throughout the process they gradually and constantly decline in number. As the curing changes are manifested only after the lapse of some time, these changes must be influenced by the products of the early activity of the bacteria; and we believe that the fundamental curing changes begin and continue during the ripening of the curd in the vat, but do not make themselves manifest till later.

8. The lactic acid bacteria in cheese, not only decrease in number with the lapse of time, but gradually lose their acid-producing power; and this circumstance, with the fact that the most rapid decline in the number of these bacilli takes place in cheese in the ordinary curing room, may give rise to a condition which is favorable to the development of any taint-producing species which may be present. Hence the cheese from a cold storage or a well regulated cool room ought to keep better than cheese from the ordinary curing room.

9. The flavor of cheese depends mainly on the breaking down of the casein under the influence of the curing agent (likely the pepsin of the rennet), aided by the acidity and other conditions produced by the growth of the lactic acid bacilli; while the most important factor in the control of these conditions is the temperature—a regular and cold or cool temperature being necessary for the best results.

10. As may be seen from the conclusions and remarks of the judges of the cheese analysed, cheese kept in cold storage at about 40 deegrees Fah., and also those kept in a well-regulated cool room, were better in flavor and body and of much greater commercial value than cheese kept in the ordinary curing room with its variable and generally too high temperature.

CHEESE OF JUNE 22ND, 1899, (KINGSTON).

| Date and Age. | | Temperature F. | | | Cheese from regulated room. | | | Temperature F. | | | Cheese from variable room. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dates of Exam. | Age in days. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. |
| | | ° | ° | ° | | | | ° | ° | ° | | | |
| June 24. ... | 2 | 65 | 61 | 62.5 | 628,750,000 | 800,000(a) | 300,000(b) | 74 | 61 | 67 | 628,750,000 | 800,000(a) | 300,000(b) |
| July 4 ..... | 12 | 65 | 56 | 61.1 | 106,560,000 | ..... | ..... | 78 | 58 | 68.5 | 78,937,500 | ..... | ..... |
| " 18..... | 26 | 64 | 58 | 61.5 | 98,750,000 | ..... | ..... | 79 | 60 | 71.6 | 63,125,000 | ..... | 40,000(c) |
| Aug. 22 ... | 61 | 65 | 56 | 62.5 | 15,000,000 | ..... | ..... | 81 | 56 | 69.1 | 4,500,000 | ..... | ..... |
| Sept. 5...... | 75 | 67 | 60 | 63.2 | 11,200,000 | ..... | ..... | 78 | 62 | 70.5 | 1,042,000 | ..... | ..... |
| " 18..... | 88 | 62 | 49 | 56 | 1,400,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| " 25..... | 95 | 65 | 51 | 59 | 2,430,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Oct. 3 ..... | 103 | 63 | 44 | 54 | 1,715,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| " 16..... | 116 | 64 | 45 | 55 | 1,650,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Nov. 23..... | 152 | . | .... | 50 | 415,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

CHEESE OF JULY 1ST, 1899, (KINGSTON).

| Dates of Exam. | Age in days. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 4...... | 3 | 63 | 61 | 62 | 461,500,000 | 2,500,000(a) | ..... | 78 | 62 | 71.3 | 454,000,000 | 1,750,000(a) | ..... |
| " 11. .... | 10 | 64 | 58 | 61.7 | 148,120,000 | ..... | 1,500,000(b) | 79 | 62 | 72.3 | 128,600,000 | ..... | 1,600,000(a) |
| " 25. ..... | 24 | 63 | 57 | 61 | 115,000,000 | 570,000(a) | ..... | 77 | 55 | 68.3 | 44,875,000 | ..... | ..... |
| Aug. 1...... | 31 | 64 | 58 | 62 | 78,315,000 | ..... | ..... | 80 | 58 | 73 | 49,300,000 | 400,000(a) | 200,000(a) |
| " 15...... | 45 | 65 | 56 | 61.8 | 43,386,000 | ..... | 115,300(d) | 79 | 56 | 68.5 | 16,750,000 | ..... | ..... |
| " 30...... | 60 | 67 | 57 | 62.5 | ..... | ..... | ..... | 81 | 58 | 70.3 | 6,375,000 | 75,000(a) | ..... |
| Sept. 18 ... | 79 | 66 | 54 | 58 | 11,020,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| " 25 ..... | 86 | 65 | 51 | 59 | 6,750,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Oct. 3 .... | 94 | 63 | 44 | 54 | 15,400,000 | 40,000(a) | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| " 16. .... | 107 | 64 | 45 | 55 | 11,300,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| " 30. .... | 121 | 65 | 50 | 55 | 5,800,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Nov. 23..... | 145 | .... | .... | 50 | 2,030,000 | ..... | 10,000(c) | ..... | ..... | ..... | ..... | ..... | ..... |

CHEESE OF JULY 7TH 1899, (KINGSTON).

| Dates of Exam. | Age in days. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 11. ... | 4 | 62 | 58 | 61 | 146,322,000 | 68,000(a) | 504,000(e) | 79 | 62 | 70.6 | 110,750,000 | 100,000(a) | 375,000(e) |
| " 18 ..... | 11 | 63 | 58 | 61.3 | 48,250,000 | ..... | 100,000(e) | 77 | 60 | 70.3 | 51,460,000 | ..... | 50,000(g) |
| " 25 ..... | 18 | 63 | 57 | 60.5 | 21,625,000 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Aug. 1...... | 25 | 64 | 58 | 62 | 24,850,000 | ..... | ..... | 80 | 55 | 69.1 | 10,250,000 | ..... | 90,000(h) |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| " 22 | 46 | 65 | 56 | 62 | 9,850,000 | | | 81 | 56 | 69 | 5,600,000 | | |
| Sept. 20 | 75 | 66 | 49 | 60 | 460,000 | | 4,000 (*b*) | | | | | | |
| Oct. 16 | 102 | 64 | 44 | 55 | 527,500 | | 5,000 (*g*) | | | | | | |
| Nov. 23 | 140 | | | 50 | 525,000 | | | | | | | | |
| **Cheese of July 13th, 1899. (Kingston).** | | | | | | | | | | | | | |
| July 18 | 5 | 63 | 58 | 61.5 | 385,000,000 | | | 77 | 60 | 70.3 | 30,865,400 | 260,000 (*a*) | |
| " 25 | 12 | 63 | 57 | 60.5 | | | | 74 | 55 | 66 | 27,083,000 | | 100,000 (*b*) |
| Aug. 1 | 19 | 64 | 58 | 62 | 39,353,000 | 150,000 (*a*) | 80,000 (*b*) | 80 | 58 | 73 | 19,440,000 | | |
| Aug. 15 | 33 | 65 | 56 | 61.8 | 22,040,000 | 150,000 (*a*) | | 79 | 56 | 68.5 | 22,937,500 | | |
| Aug. 29 | 47 | 67 | 57 | 62.5 | | | | 81 | 58 | 70.3 | 5,000,000 | 40,000 (*a*) | |
| Sept. 18 | 67 | 66 | 54 | 58 | 2,510,000 | | | | | | | | |
| " 25 | 74 | 65 | 51 | 59 | 2,880,000 | 2,000 (*a*) | | | | | | | |
| Oct. 3 | 82 | 63 | 44 | 54 | 6,070,000 | | 4,000 (*d*) | | | | | | |
| " 16 | 95 | 64 | 45 | 55 | 3,256,000 | | | | | | | | |
| Nov. 23 | 133 | | | 50 | 5-5,000 | | | | | | | | |
| **Cheese of July 19th, 1899. (Kingston).** | | | | | | | | | | | | | |
| July 25 | 6 | 63 | 57 | 60.5 | 158,150,000 | | 1,000,000 (*i*) | 74 | 55 | 66 | 108,555,000 | 700,000 (*a*) | |
| Aug. 1 | 13 | 64 | 58 | 62 | 41,300,000 | 200,000 (*a*) | | 80 | 58 | 73 | 89,777,000 | 120,000 (*a*) | |
| " 15 | 27 | 65 | 56 | 61.8 | 89,066,000 | | 200,000 (*i*) | 79 | 56 | 68.5 | 61,500,000 | | 100,000 (*i*) |
| " 22 | 34 | 64 | 57 | 62 | 86,600,000 | | | 81 | 58 | 70 | 53,000,000 | | 20,000 (*i*) |
| " 29 | 41 | 67 | 60 | 63.2 | 42,800,000 | | 20,000 (*i*) | 78 | 62 | 70.5 | 23,100,000 | | |
| Sept. 20 | 63 | 66 | 54 | 58 | 7,500,000 | | | | | | | | |
| Oct. 3 | 76 | 65 | 44 | 55 | 15,116,000 | | 40,000 (*i*) | | | | | | |
| Oct. 30 | 193 | 64 | 44 | 54 | 5,091,000 | | 10,000 (*i*) | | | | | | |
| Nov. 23 | 127 | | | 50 | 1,170,000 | | | | | | | | |
| **Cheese of July 29th, 1899. (Kingston).** | | | | | | | | | | | | | |
| Aug. 1 | 3 | 63 | 58 | 61.1 | 348,400,000 | 2,000,000 (*j*) | | 80 | 58 | 70.3 | 453,333,000 | 1,000,000 (*j*) | |
| " 15 | 17 | 65 | 56 | 61.8 | 231,800,000 | 1,000,000 (*j*) | | 79 | 56 | 68.5 | 193,500,000 | | |
| " 22 | 24 | 64 | 57 | 62 | 152,614,000 | | | 81 | 58 | 70 | | | |
| " 29 | 31 | 67 | 60 | 63.2 | 145,000,000 | | | 78 | 62 | 70.5 | 103,000,000 | | |
| Sept. 16 | 49 | 66 | 54 | 58 | 41,000,000 | | | | | | | | |

(*a*) B. coli communis. (*b*) Sarcina lutea. (*c*) A white yeast.
(*d*) Partly Sarcina lutea and partly yeasts. (*e*) B. subtilis. (*f*) Torula rosea.
(*g*) Micrococcus alba. (*h*) Orange Micrococcus.
(*i*) A small bacillus—producing a yellow colony—non-liquefying, etc. Species not determined. Is not active in milk.
(*j*) Bacillus related to Proteus group.

CHEESE OF JULY 29TH, 1899.—(*Continued.*)

| Date and Age. | | Temperature. | | | Cheese from regulated room. | | | Temperature. | | | Cheese from variable room. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dates of exam. | Age. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. |
| | | ° | ° | ° | | | | ° | ° | ° | | | |
| Oct. 2 | 65 | 65 | 44 | 55 | 10,000,000 | ........ | ........ | .... | .... | .... | ........ | ........ | ........ |
| Oct. 16 | 79 | 64 | 45 | 55 | 9,750,000 | ........ | ........ | .... | .... | .... | ........ | ........ | ........ |
| Oct 30 | 93 | 65 | 50 | 55 | 10,890,009 | ........ | ........ | .... | .... | .... | ........ | ........ | ........ |
| Nov. 23 | 117 | ... | .. | 50 | 3,520,000 | ........ | ........ | .... | .... | .... | ........ | ........ | ........ |

CHEESE OF AUGUST 10TH, 1899 (KINGSTON).

| Dates of exam. | Age. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aug. 15 | 5 | 65 | 56 | 62.4 | 536,400,000 | 100,000 (a) | ........ | 79 | 56 | 68.6 | 323,250,000 | 200,000 (a) | ........ |
| Aug. 22 | 12 | 64 | 57 | 62 | ........ | ........ | ........ | 81 | 58 | 70 | 206,400 000 | ........ | ........ |
| Aug. 29 | 19 | 67 | 60 | 63.2 | 125,000,000 | ........ | 400,000 (b) | 78 | 62 | 70 5 | 122,300,000 | ........ | ........ |
| Sept. 20 | 41 | 66 | 54 | 58 | 14,148,000 | ........ | ........ | .... | . | .... | ........ | ........ | 200,000 (b) |
| Oct. 2 | 53 | 65 | 44 | 55 | 22,200,000 | ........ | ........ | .... | .... | .... | ........ | ........ | ........ |
| " 30 | 81 | 64 | 44 | 54 | 10,935,000 | ........ | ........ | .... | .... | .... | ........ | ........ | ........ |
| Nov. 23 | 105 | ...... | ...... | 50 | 2.780,000 | ........ | 50,000 (b) | .... | .... | .. | ........ | ........ | ........ |

CHEESE OF JULY 5TH, 1900. (KINGSTON).

| Dates of exam. | Age. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Other Bact. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 11 | 6 | 64 | 60 | 62 | 387,500,000 | ........ | 1,000,000(g) | 82 | 61 | 70 | 202,135,000 | ........ | 500 000 (g) |
| " 20 | 15 | 64 | 60 | 62.5 | 12[illegible],500,000 | ........ | 640,000(g)<br>300,000(h) | 83 | 62 | 72 | 73,750,000 | ........ | 250,000 (g)<br>75,000 (g)(h) |
| " 26 | 21 | 65 | 59 | 62.5 | 56,100,000 | ........ | 500,000(g) | 82 | 68 | 74 | 29,800,000 | ........ | 350 000 (g) |
| Aug. 1 | 27 | 64 | 59 | 62.5 | 36,100,000 | ........ | 10,000(i) | 79 | 60 | 71 | 19,800,000 | ........ | 200,000 (h) |
| " 8 | 34 | 64 | 59 | 61 | 22,755,000 | ........ | ........ | 78 | 58 | 68 | 11,430,000 | ........ | 20,000<br>15,000 (g) |
| " 13 | 39 | 65 | 59 | 62.5 | 23,071,600 | ........ | 10,000(i) | 83 | 62 | 74 | 6.630,000 | ........ | 15,000 (h) |
| " 20 | 46 | 66 | 58 | 62 | 16,135,000 | ........ | ........ | 81 | 64 | 73 | 4,812,500 | ........ | ........ |
| Sept. 4 | 61 | 65 | 56 | 61 | 4,935,000 | ........ | 90,000(h) | 82 | 60 | 70 | 3,500,000 | ........ | 108,000 (h) |

CHEESE OF JULY 6TH, 1900 (KINGSTON).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 11...... | 5 | 64 | 60 | 62 | 300,000,000 | 2,600,000 | ...... | 82 | 61 | 70 | 181,800,000 | 1,260,000 | ...... |
| " 20...... | 14 | 64 | 60 | 62.5 | 164,166,000 | 1,200,000 | 240,000(g)<br>240,000(h) | 83 | 62 | 72 | 70,568,000 | 240,000 | 60,000(g) |
| " 26...... | 20 | 65 | 59 | 62.5 | 144,762,000 | 100,000 | 400,000(g) | 82 | 68 | 74 | 78,154,000 | 408,000 | 200,000(i) |
| Aug. 1...... | 26 | 64 | 59 | 62.5 | 84,300,000 | ...... | ...... | 79 | 60 | 71 | 36,250,000 | ...... | ...... |
| " 8...... | 33 | 64 | 59 | 61 | 68,520,000 | ...... | 125,000(g) | 78 | 58 | 68 | 33,127,500 | ...... | 20,000(j) |
| " 13...... | 38 | 65 | 59 | 62.5 | 40,365,000 | ...... | 125,000(g)<br>125,000(h) | 83 | 62 | 74 | 15,400,000 | ...... | 10,000(k) |
| " 20...... | 45 | 66 | 58 | 62 | 22,105,000 | ...... | 220,000(g) | 81 | 64 | 73 | 2,380,000 | ...... | 5,000(i) |
| " 27...... | 52 | 65 | 59 | 62 | 4,520,000 | ...... | ...... | 82 | 60 | 70 | 1,100,000 | ...... | ...... |

CHEESE OF JULY 7TH, 1900 (KINGSTON).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| July 11...... | 4 | 64 | 60 | 62 | 242,200,000 | ...... | ...... | 82 | 61 | 71 | 236,250,000 | ...... | ...... |
| " 20...... | 13 | 64 | 60 | 62.5 | 197,500,000 | ...... | 1,360,000(g)<br>112,000(h) | 83 | 62 | 72 | 64,881,000 | ...... | 900,000(g) |
| " 26...... | 19 | 65 | 59 | 62.5 | 66,364,000 | ...... | 360,000(g) | 82 | 68 | 74 | 52,600,000 | ...... | 200,000(h) |
| Aug. 1...... | 25 | 64 | 59 | 62.5 | 69,560,000 | 160,000 | 320,000(g) | 79 | 60 | 71 | 21,400,000 | ...... | 200,000(g) |
| " 8...... | 32 | 64 | 59 | 61 | 70,300,000 | ...... | 50,000 | 78 | 58 | 68 | 9,600,000 | ...... | 200,000(h) |
| " 13...... | 37 | 65 | 59 | 62.5 | 42,500,000 | ...... | 30,000(k) | 83 | 62 | 74 | 5,700,000 | ...... | 100,000(g)<br>50,000 |
| " 20...... | 44 | 66 | 58 | 62 | 41,700,000 | ...... | 25,000(k) | 81 | 64 | 73 | 4,942,000 | ...... | ...... |
| Sept. 4...... | 59 | 65 | 56 | 61 | 11,827,000 | ...... | ...... | 82 | 60 | 70 | 2,200,000 | ...... | 20,000(g) |

CHEESE OF JULY 18TH, 1900. VAT 1.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | * | | | | | | * | |
| July 26...... | 8 | 65 | 59 | 62.5 | 337,750,000 | ...... | ...... | 82 | 68 | 74 | 161,917,000 | ...... | ...... |
| Aug. 1...... | 14 | 64 | 59 | 62.5 | 214,800,000 | ...... | ...... | 79 | 60 | 71 | 115,200,000 | ...... | ...... |
| " 8...... | 21 | 61 | 59 | 61 | ...... | ...... | ...... | 78 | 58 | 68 | 101,800,000 | ...... | ...... |
| " 13...... | 26 | 65 | 59 | 62.5 | 107,400,000 | ...... | ...... | 83 | 62 | 74 | 45,333,000 | ...... | ...... |
| " 20...... | 33 | 66 | 58 | 62 | 62,000,000 | ...... | ...... | 81 | 64 | 73 | 17,752,000 | ...... | ...... |
| Sept. 4...... | 48 | 65 | 56 | 61 | 14,226,000 | ...... | ...... | 82 | 60 | 70 | 4,225,000 | ...... | ...... |

(a) B. coli communis. (b) Sarcina lutea.
(g) A bacillus, non-liquefying, producing a light yellow pigment. (h) B. fluorescens liquefaciens. (i) Torula alba.
(j) B. megatherium. (k) A liquefying streptococcus. *The bacteria apart from the Lactic acid bacteria were not calculated.

| Date and Age. | | Temperature. | | | Kept in regulated room. | | | Temperature. | | | Kept in ordinary room. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date. | Age. | Max. | Min. | Aver. | Lactic acid Bact. | Gas formers. | Other Bact. | Max. | Min. | Aver. | Lactic acid Bact. | Gas formers. | Other Bact. |
| | | ° | ° | ° | | | | ° | ° | ° | | | |
| **Cheese of July 18th. Vat. 3.** | | | | | | | | | | | | | |
| July 26.... | 8 | 65 | 59 | 62.5 | 161,430,000 | .... | .... | 82 | 68 | 74 | 344,375,000 | .... | .... |
| Aug. 1...... | 14 | 64 | 59 | 62.5 | .... | .... | .... | 79 | 60 | 71 | 210,000,000 | .... | .... |
| " 8..... | 21 | 64 | 59 | 61 | 331,250,000 | .... | .... | 78 | 58 | 68 | 62,000,000 | .... | .... |
| " 13...... | 26 | 65 | 59 | 62.5 | 173,000,000 | .... | .... | 83 | 62 | 74 | 48,420,000 | .... | .... |
| " 20...... | 33 | 66 | 58 | 62 | 92,300,000 | .... | .... | 81 | 64 | 73 | .... | .... | .... |
| Sept 4..... | 48 | 65 | 56 | 61 | 40,950,000 | .... | | 82 | 60 | 70 | 12,420,000 | .... | .... |
| **Cheese of July 19th, Vat 1. (Kingston).** | | | | | | | | | | | | | |
| July 26.... | 7 | 65 | 59 | 62 5 | 331,666,000 | .... | .... | 82 | 68 | 74 | 290,000,000 | .... | .... |
| Aug. 1...... | 13 | 64 | 59 | 62 5 | 198,000,000 | .... | .... | 79 | 60 | 71 | 226,000,000 | .... | .... |
| " 8...... | 20 | 64 | 59 | 61 | 89,773,000 | .... | .... | 78 | 58 | 68 | 156,750,000 | .... | .... |
| " 13...... | 25 | 65 | 59 | 62.5 | 35,000,000 | .... | .... | 83 | 62 | 74 | 26,563,500 | .... | .... |
| " 20...... | 32 | 66 | 58 | 62 | 69,000,000 | .... | .... | 81 | 64 | 73 | 7,725,000 | .... | .... |
| Sept. 1..... | 43 | 65 | 58 | 61 | 17,520,000 | .... | .... | 82 | 60 | 70 | 2,781,000 | .... | .... |
| **Cheese of July 1st, 1900.** | | | | | | | | | | | | | |
| July 26..... | 7 | 65 | 59 | 62.5 | 344,950,000 | .... | .... | 82 | 68 | 74 | 382,750,000 | .... | .... |
| Aug. 1...... | 13 | 64 | 59 | 62.5 | 90,450,000 | .... | .... | 79 | 60 | 71 | 228,365,000 | .... | .... |
| " 8..... | 20 | 64 | 59 | 61 | 110,625,000 | .... | .... | 78 | 58 | 68 | 73,145,000 | .... | .... |
| " 13..... | 25 | 65 | 59 | 62.5 | 125,000,000 | .... | .... | 83 | 62 | 74 | 22,550,000 | .... | .... |
| " 20...... | 32 | 66 | 58 | 62 | 57,500,000 | .... | .... | 81 | 64 | 73 | 11,775,000 | .... | .... |
| Sept. 1...... | 43 | 65 | 58 | 61 | 18,057,142 | .... | .... | 82 | 60 | 70 | 3,750,000 | .... | .... |

### CHEESE OF APRIL 26,—A. REFRIGERATOR. (GUELPH).

| Date. | Age. | Temperature. Max. | Min. | Av. | Lactic acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| | | ° | ° | ° | | | | |
| April 26 ..... | 1 | 38 | 35 | 36.5 | 543,000,000 | ........ | ........ | ........ |
| May 13....... | 17 | 38 | 36 | 37 | 566,000,000 | ........ | ........ | 130,000 |
| " 21....... | 25 | 38 | 36 | 37 | 547,650,000 | ........ | ........ | 238,000 |
| " 28....... | 32 | 38 | 38 | 37 | 448,700,000 | ........ | ........ | 270,000 |
| June 6 ..... | 41 | 39 | 37 | 38 | 504,300,000 | ........ | ........ | 120,000 |
| " 13 ..... | 48 | 40 | 37 | 38.5 | 477,000 000 | ........ | ........ | ........ |
| " 22 ..... | 57 | 42 | 38 | 40 | 155,500,000 | ........ | ........ | ........ |
| July 16....... | 81 | 42 | 39 | 40.5 | 44,500,000 | ........ | ........ | ........ |
| Aug. 5........ | 101 | 42 | 38 | 40 | 44,250,000 | ........ | ........ | ........ |

### CHEESE OF APRIL 26TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| Date. | Age. | Max. | Min. | Av. | Lactic acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| April 26 ..... | 1 | 65 | 55 | 60 | 543,000,000 | ........ | ........ | ........ |
| May 6........ | 10 | 65 | 55 | 60 | 390,000,000 | ........ | 2,000,000($g$) | ........ |
| " 28...... | 32 | 38 | 38 | 38 | 123,800,000 | ........ | 400,000($g$) | ........ |
| June 6........ | 41 | 39 | 37 | 38 | 166,800,000 | ........ | ........ | ........ |
| " 13.. ..... | 48 | 40 | 37 | 38.5 | 117,300,000 | ........ | ........ | ........ |
| " 22.... ... | 57 | 42 | 38 | 40 | 27,200,000 | ........ | ........ | ........ |

### CHEESE OF APRIL 26TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| Date. | Age. | Max. | Min. | Av. | Lactic acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| April 26...... | 1 | 65 | 55 | 60 | 543,000,000 | ........ | ........ | ........ |
| May 11....... | 16 | 65 | 55 | 60 | 146,500,000 | ........ | 310,000($g$) | ........ |
| " 28....... | 32 | 38 | 38 | 38 | 123,700,000 | ........ | 70,000($g$) | ........ |
| June 6 .... . | 41 | 39 | 37 | 38 | 124,200,000 | ........ | ........ | ........ |
| " 13....... | 48 | 40 | 37 | 38 5 | 74,000 000 | ........ | ........ | ........ |
| " 22....... | 57 | 42 | 38 | 40 | 32,000,000 | ........ | ........ | ........ |

### CHEESE OF APRIL 26TH,—E. ORDINARY CURING ROOM.

| Date. | Age. | Max. | Min. | Av. | Lactic acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| April 26...... | 1 | 65 | 55 | 60 | 543,000,000 | ........ | ........ | ........ |
| May 28....... | 32 | 70 | 65 | 63 | 122,000,000 | ........ | 400,000($g$) | ........ |
| June 6 ...... | 41 | 70 | 62 | 66 | 28,250,000 | ........ | 105,000($g$) | ........ |
| " 13 ...... | 48 | 73 | 58 | 64 | 26,000 000 | ........ | 72,000($g$) | ........ |
| " 22 .... . | 57 | 74 | 58 | 67 | 9,234,000 | ........ | ........ | ........ |
| July 16....... | 81 | 80 | 68 | 75 | 3,430,000 | ........ | ........ | ........ |

### CHEESE OF APRIL 29TH,—A. REFRIGERATOR. (GUELPH).

| Date. | Age. | Max. | Min. | Av. | Lactic acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| May 2 ....... | 3 | 38 | 37 | 37.5 | 486,000,000 | 582 000($a$) | 194,000($b$) | 1,500,000 |
| " 21........ | 22 | 38 | 36 | 37 | 541,000,000 | 210,000($a$) | ........ | 630,000 |
| " 28 ....... | 29 | 38 | 38 | 38 | 519,000 000 | ........ | ........ | ........ |
| June 6....... | 38 | 39 | 37 | 38 | 482 000,000 | ........ | ........ | 182,000 |
| " 12....... | 44 | 40 | 37 | 38.5 | 310,000,000 | ........ | 91,000($b$) | ........ |
| " 22. .... | 54 | 42 | 38 | 40 | 261,000,000 | ........ | ........ | ........ |
| July 16. ..... | 78 | 42 | 39 | 40.5 | 73,800,000 | ........ | ........ | ........ |
| Aug. 7. .... | 100 | 42 | 38 | 40 | 42,300,000 | ........ | ........ | ........ |

($a$) B. lactis aërogenes. ($b$) Partly M. aureus lactis. ($g$) B. subtilis group.

CHEESE OF APRIL 29TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| Date. | Age. | Temperature. | | | Lactic acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Av. | | | | |
| May 2... | 3 | 65° | 55° | 60° | 486,000,000 | 582,000(*a*) | 194,000(*b*) | 1,500,000 |
| " 7... | 8 | 65 | 55 | 60 | 169,000,000 | ............ | 132,000(*b*) | 760,000 |
| " 28... | 29 | 38 | 38 | 38 | 138,000,000 | .. ... .... | ............. | 186,200 |
| June 6... | 38 | 39 | 37 | 38 | 106,800,000 | ........... | ............. | ........ |
| " 13... | 45 | 40 | 37 | 38.5 | 93,800,000 | .. ... ..... | 126,000(*b*) | .. ...... |
| " 22... | 54 | 42 | 38 | 40 | 88,150,000 | ............ | ............. | .......... |

CHEESE OF APRIL 29TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 2... | 3 | 65 | 55 | 60 | 486,000,000 | 582,000(*a*) | 194,000(*b*) | 1,500,000 |
| " 14... | 15 | 66 | 55 | 61 | 117,600,000 | ............ | ............ | .......... |
| " 28.. | 29 | 38 | 38 | 38 | 77,700,000 | ............ | .............. | ...... .... |
| June 6... | 38 | 39 | 37 | 38 | 75,500,000 | ............ | .............. | .......... |
| " 13.. | 45 | 40 | 37 | 38.5 | 57,000,000 | ...... .... | .............. | .... ..... |
| " 22... | 54 | 42 | 38 | 40 | 54,000,000 | ....... .... | .............. | .......... |

CHEESE OF APRIL 29TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 2... | 3 | 65 | 55 | 60 | 486,000,000 | 582,000(*a*) | 194,000(*b*) | 1,500,000 |
| " 21... | 22 | 70 | 55 | 63 | 129,000,000 | .......... | ............. | .... .... |
| " 28... | 29 | 38 | 38 | 38 | 120,100,000 | ....... .... | ......... ... | ..... .... |
| June 6... | 38 | 39 | 37 | 38 | 119,600,000 | ............ | .............. | .......... |
| " 13... | 45 | 40 | 37 | 38.5 | 35,000,000 | ............ | ..... ..... .. | .......... |
| " 22... | 54 | 42 | 38 | 40 | 30,500,000 | .......... . | .. .......... | ..... .... |

CHEESE OF APRIL 29TH,—E. ORDINARY CURING ROOM.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 2... | 3 | 65 | 55 | 60 | 486,000,000 | 582,000(*a*) | 194,000(*b*) | 1,500,000 |
| June 6... | 38 | 70 | 62 | 66 | 45,000,000 | 119,000(*a*) | .............. | .......... |
| " 13... | 45 | 73 | 58 | 64 | 39,700,000 | .... .. .. | ........ .... | .......... |
| " 22... | 54 | 74 | 58 | 67 | 5,300,000 | ............ | .............. | .......... |
| July 16... | 78 | 80 | 68 | 75 | 2,750,000 | ............ | .............. | .......... |

CHEESE OF MAY 6TH,—A. REFRIGERATOR. (GUELPH.)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 6... | 1 | 39 | 37 | 38 | 523,000,000 | 1,000,000(*a*) | .............. | 500,000 |
| " 21... | 15 | 38 | 36 | 37 | 489,000,000 | 500,000(*a*) | .............. | .......... |
| " 29... | 23 | 38 | 38 | 38 | 482,000,000 | .......... | ............ | ........ . |
| June 4... | 29 | 39 | 37 | 38 | 475,000,000 | ............ | ....... .. ... | .......... |
| " 19... | 44 | 42 | 38 | 40 | 397,000,000 | ............ | ......... .... | ..... ... |
| " 29... | 54 | 42 | 38 | 40 | 471,000,000 | ............ | .............. | .......... |
| July 16... | 71 | 42 | 39 | 40.5 | 473,000,000 | ............ | .............. | .......... |
| Aug. 7... | 93 | 42 | 38 | 40 | 437,000,000 | ............ | .............. | .......... |

(*a*) B. lactis aërogenes. (*b*) Partly M. aureus lactis.

Cheese of May 6th,—B. One Week in Ordinary Curing Room and then into Refrigerator.

| Date. | Age. | Temperature. | | | Lactic Acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Av. | | | | |
| | | ° | ° | ° | | | | |
| May 6. . | 1 | 64 | 56 | 60 | 523,000,000 | 1,000,000(*a*) | .............. | 500,000 |
| " 14... | 8 | 65 | 55 | 60 | 263,000,000 | 750,000(*a*) | .............. | .......... |
| " 29... | 23 | 38 | 38 | 38 | 274,000,000 | ............ | .............. | .......... |
| June 4... | 29 | 39 | 37 | 38 | 255,100,000 | ............ | .............. | .......... |
| " 12... | 37 | 40 | 37 | 38.5 | 200,2[illegible]0,000 | ............ | .............. | .......... |
| " 20... | 45 | 42 | 38 | 40 | 118,000,000 | ............ | .............. | .......... |
| " 29... | 54 | 42 | 38 | 40 | 110,000,000 | ............ | .............. | .......... |

Cheese of May 6th, —C. Two Weeks in Ordinary Curing Room and then into Refrigerator.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 6... | 1 | 64 | 56 | 60 | 523,000,000 | 1,000,000(*a*) | .............. | 500,000 |
| " 21... | 15 | 70 | 55 | 63 | 145,000,000 | ............ | .............. | .......... |
| " 29... | 23 | 38 | 38 | 38 | 152,000,000 | ............ | .............. | .......... |
| June 4. . | 29 | 39 | 37 | 38 | 141,500,000 | ............ | .............. | .......... |
| " 12... | 37 | 40 | 37 | 38.5 | 128,700.000 | ............ | .............. | .......... |
| " 29... | 54 | 42 | 38 | 40 | 109,000,000 | ............ | .............. | .......... |

Cheese of May 6th,—D. Three Weeks in Ordinary Curing Room and then into Refrigerator.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 6... | 1 | 64 | 56 | 60 | 523,000,000 | 1,000,000(*a*) | .............. | 500,000 |
| " 14... | 8 | 65 | 55 | 60 | 263,000,000 | 750,000(*a*) | .............. | .......... |
| " 21... | 15 | 70 | 55 | 63 | 145,000,000 | ............ | .............. | .......... |
| " 29... | 23 | 69 | 58 | 64 | 195,000 000 | ............ | .............. | .......... |
| June 4... | 29 | 39 | 37 | 38 | 161,000,000 | ............ | .............. | .......... |
| " 12... | 37 | 40 | 37 | 38.5 | 102,000,000 | ............ | .............. | .......... |
| " 20... | 45 | 42 | 38 | 40 | 104,500,000 | ............ | .............. | .......... |
| " 29... | 54 | 42 | 38 | 40 | 72,500,000 | ............ | .............. | .......... |

Cheese of May 6th,—E. Ordinary Curing Room.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 6.... | 1 | 64 | 56 | 60 | 523,000,000 | 1,000,000(*a*) | .............. | 500,000 |
| " 14... | 8 | 65 | 55 | 60 | 263,000,000 | 750 000(*a*) | .............. | .......... |
| " 21... | 15 | 70 | 55 | 63 | 145,000,000 | 560,000(*a*) | .............. | .......... |
| " 29... | 23 | 69 | 58 | 64 | .......... | ............ | .............. | .......... |
| June 4.. | 29 | 70 | 62 | 66 | 97,000,000 | ............ | .............. | .......... |
| " 12.. | 37 | 73 | 58 | 64 | 82,600,000 | ............ | .............. | .......... |
| " 20.. | 45 | 74 | 58 | 67 | 37,000,000 | ............ | .............. | .......... |
| " 29.. | 54 | 68 | 57 | 64 | 12,000,000 | ............ | .............. | .......... |
| July 16.. | 71 | 80 | 68 | 75 | 4,100,000 | ............ | .............. | .......... |

(*a*) B. lactis aërogenes.

CHEESE OF MAY 13TH,—REFRIGERATOR. (GUELPH).

| Date. | Age. | Temperature. | | | Lactic Acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Av. | | | | |
| | | ° | ° | ° | | | | |
| May 13.. | 1 | 38 | 36 | 37 | 623,000,000 | 1,200,000(*a*) | 2,400,000(*d*)(*g*) | 1,200,000 |
| " 21.. | 8 | 38 | 36 | 37 | 612,000,000 | 800,000(*a*) | 1,600,000(*d*)(*g*) | ... . ... |
| " 29.. | 16 | 38 | 38 | 38 | 615,000,000 | .... ..... | 710,000(*d*)(*g*) | .......... |
| June 6... | 24 | 39 | 37 | 38 | 596,600,000 | 450,000(*a*) | 900,000(*d*)(*g*) | .......... |
| " 12.. | 30 | 40 | 37 | 38.5 | 561,500,000 | .......... | ............. | .......... |
| " 21.. | 39 | 42 | 38 | 40 | 461,000,000 | ........... | ............. | .......... |
| " 24.. | 42 | 42 | 38 | 40 | 360,000,000 | ..... ..... | ............. | .......... |
| July 16.. | 64 | 42 | 39 | 40.5 | 431,000,000 | .......... | ............. | ........ |
| Aug. 7... | 86 | 42 | 38 | 40 | 358,000,000 | ....... .... | . .... ....... | .... ..... |

CHEESE OF MAY 13TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 13.. | 1 | 65 | 55 | 60 | 623,000,000 | 1,200,000(*a*) | 2,400,000(*d*)(*g*) | 1,200,000 |
| " 21.. | 8 | 70 | 55 | 63 | 290,000,000 | 400,000(*a*) | 800.000(*d*)(*g*) | 800,000 |
| " 29.. | 16 | 38 | 38 | 38 | 162,000,000 | ...... .... | .... ......... | .......... |
| June 5... | 23 | 39 | 37 | 38 | 135,000,000 | 270,000(*a*) | ............. | ..... .... |
| " 12.. | 30 | 40 | 37 | 38.5 | 147,000,000 | ... . ..... | ............. | .......... |
| " 21.. | 39 | 42 | 38 | 40 | 209,000,000 | ..... ...... | ............. | . ... .... |
| " 28.. | 46 | 42 | 38 | 40 | 171,000,000 | ........... | ............. | . .. .... |

CHEESE OF MAY 13TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 13.. | 1 | 65 | 55 | 60 | 623,000,000 | 1,200,000(*a*) | 2,400,000(*d*)(*g*) | 1,200.000 |
| " 21. | 8 | 70 | 55 | 63 | 290,000,000 | 400,000(*a*) | 800,000(*d*)(*g*) | 800,000 |
| " 29.. | 16 | 69 | 58 | 64 | 229,000,000 | ...... ..... | 220,000(*d*)(*g*) | .... ..... |
| June 5... | 23 | 39 | 37 | 38 | 155,000 000 | 175,000(*a*) | ............. | .......... |
| " 12.. | 30 | 40 | 37 | 38.5 | 162,000,000 | ........... | ............. | .......... |
| " 21.. | 39 | 42 | 38 | 40 | 137,000,000 | ..... ...... | ............. | ......... |
| " 28.. | 46 | 42 | 38 | 40 | 133,000,000 | ........... | .. ... ...... | ... ..... |

CHEESE OF MAY 13TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 13... | 1 | 65 | 55 | 60 | 623,000,000 | 1,200,000(*a*) | 2.400,000(*d*)(*g*) | 1,200,000 |
| " 21.. | 8 | 70 | 55 | 63 | 290.000,000 | 400,000(*a*) | 800,000(*d*)(*g*) | 800,000 |
| " 29.. | 16 | 69 | 58 | 64 | 229,000,000 | ........... | 200,000(*d*)(*g*) | .......... |
| June 4... | 22 | 70 | 62 | 66 | 94,000,000 | 145,000(*a*) | ............. | ....... .. |
| " 12.. | 30 | 40 | 37 | 38.5 | 104,000,000 | ...... ... | ............. | ..... .... |
| " 21.. | 39 | 42 | 38 | 40 | 106,000,000 | ........... | ............. | .......... |
| " 28.. | 46 | 42 | 38 | 40 | 87,000,000 | ... | .. .... | .......... |

CHEESE OF MAY 13TH,—E. IN ORDINARY CURING ROOM.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 13.. | 1 | 65 | 55 | 60 | 623,000,000 | 1,200,000(*a*) | 2,400,000(*d*)(*g*) | 1,200,000 |
| " 21.. | 8 | 70 | 55 | 63 | 290 000,000 | 400,000(*a*) | 800,000(*d*)(*g*) | 800,000 |
| " 29.. | 16 | 69 | 58 | 64 | 229,000,000 | .. | 220,000(*d*)(*g*) | .......... |
| June 4... | 22 | 70 | 62 | 66 | 154,000,000 | 175.000(*a*) | ............. | .......... |
| " 11.. | 29 | 73 | 58 | 64 | 90,000,000 | 90,000(*a*) | ............. | .......... |
| " 21.. | 39 | 74 | 58 | 67 | 86,000,000 | .......... | .. . ......... | .......... |
| " 29.. | 47 | 68 | 57 | 64 | 24,000,000 | ........ | ............. | ... ..... |
| July 16... | 64 | 80 | 68 | 75 | 17 000,000 | .... | .... .. | ........ |

(*a*) B. lactis aërogenes. (*d*) M. varians lactis. (*g*) B. subtilis.

CHEESE OF MAY 20TH,—A. REFRIGERATOR. (GUELPH).

| Date. | Age. | Temperature. Max. | Min. | Av. | Lactic Acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| | | ° | ° | ° | | | | |
| May 20... | 1 | 38 | 36 | 37 | 500,000,000 | 1,000,000(*c*) | 95,000(*e*) | .......... |
| " 28.. | 8 | 38 | 38 | 38 | 473,000,000 | ...... .... | ........... .. | ......... |
| June 4... | 15 | 39 | 37 | 38 | 490,000,000 | ...... ..... | ........ ..... | ......... |
| " 11... | 22 | 40 | 37 | 38.5 | 446,000,000 | 125,000(*c*) | ............. | ......... |
| " 18... | 29 | 42 | 38 | 40 | 496,000,000 | .. .. ...... | ............ | ......... |
| " 27... | 38 | 42 | 38 | 40 | 491,000,000 | ........... | ............ | ......... |
| July 18... | 59 | 42 | 39 | 40.5 | 445,000,000 | ........... | ...... ...... | ......... |
| Aug. 7.... | 79 | 42 | 38 | 40 | 431,000,000 | ........... | .......... .. | ......... |

CHEESE OF MAY 20TH,—B. ONE WEEK IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 20... | 1 | 70 | 55 | 63 | 500,000,000 | 1,000,000(*c*) | 98,000(*e*)(*d*) | .......... |
| " 28... | 8 | 69 | 58 | 64 | 456,000,000 | 620,000(*c*) | 310,000(*e*)(*d*) | .......... |
| June 4... | 15 | 39 | 37 | 38 | 455,000,000 | ........... | ............. | .......... |
| " 11... | 22 | 40 | 37 | 38 5 | 350,000,000 | 123,000(*c*) | ............. | .......... |
| " 18 .. | 29 | 42 | 38 | 40 | 378,000,000 | ........... | ............. | ..... ... |
| " 28... | 39 | 42 | 38 | 40 | 296,000,000 | ........... | ............ | ......... |

CHEESE OF MAY 20TH,—C. TWO WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 20... | 1 | 70 | 55 | 63 | 500,000,000 | 1,000,000(*c*) | 95,000(*e*) | .......... |
| " 28... | 8 | 69 | 58 | 64 | 456,000,000 | 620,000 | 310,000(*e*)(*d*) | .......... |
| June 4... | 15 | 70 | 62 | 66 | 329 000,000 | 200,000 | ............. | .......... |
| " 11... | 22 | 40 | 37 | 38.5 | 313,000,000 | ..... .... | ......... .. | .......... |
| " 19... | 30 | 42 | 38 | 40 | 289,000,000 | ........... | ............. | ......... |
| " 29... | 40 | 42 | 38 | 40 | 216,000,000 | ........... | .. ......... . | .......... |

CHEESE OF MAY 20TH,—D. THREE WEEKS IN ORDINARY CURING ROOM AND THEN INTO REFRIGERATOR.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 20... | 1 | 70 | 55 | 63 | 500,000,000 | 1,000,000(*c*) | 95,000(*e*) | .......... |
| " 28... | 8 | 69 | 58 | 64 | 456,000,000 | 620,000(*c*) | 310,000(*e*)(*d*) | .......... |
| June 4... | 15 | 70 | 62 | 66 | 320,000,000 | 200,000(*c*) | ............. | .......... |
| " 11... | 22 | 73 | 58 | 64 | 172,000,000 | ........... | ............. | ....... |
| " 19... | 30 | 42 | 38 | 40 | 139,000,000 | ........... | ............. | .... .... |
| " 29... | 40 | 42 | 38 | 40 | 116,000,000 | .......... | .. ... ....... | ..... .... |

CHEESE OF MAY 20TH,—E. ORDINARY CURING ROOM.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 20... | 1 | 70 | 55 | 63 | 500,000,000 | 1,000,000(*c*) | 95,000(*c*) | .......... |
| " 28... | 8 | 69 | 58 | 64 | 337,000,000 | ........... | ............. | .......... |
| June 18.. | 29 | 74 | 58 | 67 | 123,000,000 | 210,000(*c*) | ............. | .......... |
| " 29.. | 40 | 68 | 57 | 64 | 41,000,000 | ........... | 82,000(*d*) | .......... |
| July 9.... | 50 | 80 | 68 | 74 | 3,000,000 | .......... | ............. | .......... |

(*c*) B. coli and B. lactis aërogenes. (*d*) M. varians lactis. (*e*) B. fulvus.

CHEESE OF MAY 27TH,—A. REFRIGERATOR (GUELPH).

| Date. | Age. | Temperature. | | | Lactic Acid Bact. | Gas formers. | Digestors. | Other Bact. |
|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Av. | | | | |
| | | ° | ° | ° | | | | |
| May 27... | 1 | 38 | 38 | 38 | 635,000,000 | ........... | ........... | ........... |
| June 4... | 8 | 39 | 37 | 38 | 520,000,000 | ........... | ........... | ........... |
| " 11... | 15 | 40 | 37 | 38.5 | 475,000,000 | ........... | ........... | ........... |
| " 18... | 22 | 42 | 38 | 40 | 477,000,000 | ........... | ........... | ........... |
| " 25... | 29 | 42 | 38 | 40 | 494,000,000 | ........... | ........... | ........... |
| July 18... | 52 | 42 | 39 | 40.5 | 253,000,000 | ........... | ........... | ........... |
| Aug. 7... | 72 | 42 | 38 | 40 | 255,000,000 | ........... | ........... | ........... |

CHEESE OF MAY 27TH,—E. ORDINARY CURING ROOM.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 27... | 1 | 69 | 58 | 64 | 635,000,000 | ........... | ........... | ........... |
| June 4... | 8 | 70 | 62 | 66 | 273,000,000 | ........... | ........... | ........... |
| " 11... | 15 | 73 | 58 | 64 | 264,000,000 | ........... | ........... | ........... |
| " 25... | 29 | 74 | 58 | 67 | 175,000,000 | ........... | ........... | ........... |
| Aug. 7... | 72 | 71 | 62 | 67 | 32,000,000 | ........... | ........... | ........... |

CHEESE OF JUNE 3RD,—A. REFRIGERATOR (GUELPH).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| June 3... | 1 | 39 | 37 | 38 | 584,000,000 | 7,000,000(*c*) | 800,000(*g*) | ........... |
| " 11... | 8 | 40 | 37 | 38.5 | 494,000,000 | 2,000,000(*c*) | ........... | ........... |
| " 18... | 15 | 42 | 68 | 40 | 366,000,000 | 420,000(*c*) | ........... | ........... |
| " 24... | 21 | 42 | 88 | 40 | 308,000,000 | 114,000(*c*) | ........... | ........... |
| July 15... | 45 | 42 | 39 | 40.5 | 302,000,000 | ........... | ........... | ........... |

CHEESE OF JUNE 3RD,—E. ORDINARY CURING ROOM.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| June 3... | 1 | 70 | 62 | 66 | 584,000,000 | 7,000,000(*c*) | 800,000(*g*) | ........... |
| " 11... | 8 | 73 | 58 | 64 | 341,000,000 | 1,630,000(*c*) | ........... | ........... |
| " 18... | 15 | 74 | 58 | 67 | 291,000,000 | 1,212,000(*c*) | ........... | ........... |
| " 24... | 21 | 74 | 58 | 67 | 209,000,000 | 80,000(*c*) | ........... | ........... |
| July 15... | 45 | 80 | 68 | 75 | 161,000,000 | 523,000(*c*) | ........... | ........... |
| " 25... | 55 | 77 | 61 | 69 | 87,000,000 | ........... | ........... | ........... |
| Aug. 9... | 70 | 71 | 62 | 67 | 4,200,000 | ........... | ........... | ........... |

(*c*) B. coli and B. lactis aërogenes.
(*g*) B. subtilis and B. halofaciens.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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| Serial No. | Date. | | Title. | Author. |
|---|---|---|---|---|
| 101 | April | 1896 | Dairy Bulletin (out of print, see No. 114)........ | Dairy School O.A.C. |
| 102 | May | 1896 | Experiments in Cheesemaking ................ | H. H. Dean |
| 103 | Aug. | 1896 | Experiments with Winter Wheat.............. | C. A. Zavitz |
| 104 | Dec. | 1896 | Rations for Dairy Cows (out of print) .......... | G. E. Day |
| 105 | April | 1897 | Instructions in Spraying (out of print see No.122). | J. H. Panton |
| 106 | June | 1897 | The San Jose Scale................ .......... | J. H. Panton |
| 107 | May | 1898 | Dairy Bulletin (out of print, see No. 114) . .... | Dairy School |
| 108 | Aug. | 1898 | Experiments with Winter Wheat .............. | C. A. Zavitz |
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| 113 | March | 1901 | Sugar Beet Experiments in Ontario............ | A. E. Shuttleworth |
| 114 | May | 1901 | Dairy Bulletin .... ..... ..... .......... . | Dairy School |
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| | | | Notes on Varieties of Winter Wheat .......... | C. A. Zavitz |
| 116 | Aug. | 1901 | The Hessian Fly in Ontario.................... | Wm. Lochhead |
| 117 | Jan. | 1902 | Pasteurization of Milk for Butter-making ...... | H. H. Dean<br>F. C. Harrison |
| 118 | Jan. | 1902 | Yeast and its Household Use .... ............. | F. C. Harrison |
| 119 | April | 1902 | Ventilation of Farm Stables and Dwellings .... | J. B. Reynolds |
| 120 | May | 1902 | Bitter Milk and Cheese ...................... | F. C. Harrison |
| 121 | June | 1902 | Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Rooms ... | H. H. Dean<br>F. C. Harrison |
| 122 | June | 1902 | Spray Calendar ............................. | Wm. Lochhead |
| 123 | July | 1902 | Cold Storage of Fruit ......... ............... | J. B. Reynolds<br>H. L. Hutt |
| 124 | Dec. | 1902 | Nature Study, or Stories in Agriculture .... ... | Staff, O. A. C. |
| 125 | Dec. | 1902 | Roup (A Disease of Poultry) .................. | F. C. Harrison<br>H. Streit |
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| 128 | Aug. | 1903 | The Weeds of Ontario ....................... | F. C. Harrison<br>W. Lochhead |
| 129 | Dec. | 1903 | Bacon Production .......................... | G. E. Day |
| 130 | Dec. | 1903 | Bacterial Content of Cheese Cured at Different Temperatures.................. ..... .... | F. C Harrison<br>W. T. Connell |

ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 131.

# Ripening of Cheese in Cold Storage

Compared with

# Ripening in the Ordinary Curing Room

BY

H. H. DEAN, B.S.A., Professor of Dairy Husbandry,

AND

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BULLETIN 131 December, 1903

Ontario Agricultural College and Experimental Farm.

# RIPENING OF CHEESE IN COLD STORAGE.

By Prof. H. H. Dean, B.S.A., and Prof. R. Harcourt, B.S.A.

The following results have been obtained in continuing the experiments relating to the ripening of cheese in cold storage. Bulletin No. 121, published in June, 1902, gave the results of experiments conducted in 1901, which were reported as preliminary. The experiments of 1902 are a continuation and extension of the work.

Possibly no phase of the cheese industry has received so much attention in recent years, as the ripening of cheese at low temperatures. The season of 1902 was phenomenally cool, and Canadian cheese never enjoyed so good a reputation in British markets, as they did last season. This was partly due to the scarcity of cheese, but the cool season, no doubt, had a great deal to do with it; thus was demonstrated in a very forcible way the great value of low temperatures in the manufacture and transportation of Canadian cheese.

### Nature of the Experiments.

The experiments of 1902 were divided into eight series or groups as follows:

1. Four cheese, marked A, B, C and E, weighing about thirty pounds each, were made from one vat of milk. A was placed, directly from the press, in an ice cold storage, which had an average temperature of 38.9. The lowest average monthly temperature was 37 degrees in April, the highest was 40.5 degrees in August. B was placed in an ordinary ripening room, which had an average temperature of 62 degrees, for one week, when it was moved to the ice cold storage. The highest monthly average of this ripening room was 66.2 degrees in July and the lowest 58.2 degrees in October. C was also placed in the ordinary ripening room and moved to the cold storage room at the end of two weeks. E was allowed to remain in the ripening room all the time. (The D cheese, which was moved to the cold storage at the end of three weeks in the experiments of 1901, was dropped from the tests in 1902.)

2. Five cheese, weighing about 30 pounds each, were made from one vat of milk and marked A, B, C, D, and E. The first four were placed at once, after taking them from the press, into an ice cold storage, while the fifth (E) was put in the ordinary ripening room, and remained there all the time. The A cheese remained in the cold storage during all the time of the experiments. B was moved to the ordinary ripening room, which had an average temperature of 62 degrees, at the end of one month. C was moved from the cold storage at the end of two months, and D at the end of three months.

The object of this experiment was to see what effect the changing of cheese, from a cold storage to an ordinary cool temperature, would have on the quality of the cheese.

3. The third series related to the effect on cheese of using an extra quantity of rennet (6 ounces per 1,000 pounds milk) in the milk as compared with the regular quantity of three and a third ounces per 1,000 pounds milk. The A cheese were placed directly in cold storage, the E in an ordinary ripening room,

while the B and C were moved from the ripening room to cold storage at the end of one and two weeks respectively, as in series 1.

4. Series 4 consisted of two sets of experiments. In both cases the cheese were made by using a large quantity of rennet (6 ounces per 1,000 pounds milk) cooking to 94 degrees instead of 98 degrees, and using one-half pound less (two pounds instead of two and one-half) salt per 100 pounds curd. One-half the cheese were ripened in an ordinary ripening room and the other half in an ice cold storage.

5. In the fifth series the curds were salted at the rate of two and a quarter pounds salt per 100 pounds curd as compared with two and three-quarter pounds salt per 100 pounds curd. Both lots were ripened in cold storage.

6. Five cheese, marked A, B, C, D, E, were made from one vat of milk. A and B were taken from the press to cold storage. A was put on a shelf and turned regularly, while B was placed in a cheese box and not turned. C, D, and E were put in the ripening room where E remained, but C and D were moved to the cold storage at the end of one week. C was placed on a shelf and turned regularly, while D was put in a cheese box and not turned.

7. This series related to the effect of formalin sprayed on the cheese and in the box to prevent mould.

8. Cheese were dipped in melted paraffine wax, which was at a temperature of about 180 degrees. Some of the cheese were placed in cold storage and some in an ordinary ripening room. A portion were dipped in the wax directly from the press, some at the end of one week, some at the end of two weeks and some at the end of three weeks, and the remainder were not coated with the paraffine.

## Results of the Experiments.

### *1. Cheese Ripened in Cold Storage and the Ordinary Ripening Room.*

From April 14th to September 15th, 1902, six lots of cheese were made—24 cheese in all. Six of these (the A's) were placed directly into cold storage from the press. The remaining eighteen were placed in the ripening room, six of which (B's) were removed to the cold storage at the end of a week, another six (C's) were moved into the cold storage at the end of two weeks, while the remaining six (E's) were allowed to ripen in the ordinary room.

The A cheese lost an average of 2.26 per cent. in weight at the end of one month. The B cheese lost an average of 2.90 per cent. in the same time. The C lost 3.20 per cent., and the E cheese 4.21 per cent. in weight at the end of one month.

The cheese were all scored from one to four times. The first scoring of the E cheese was made in from six weeks to two months after they were made, while the cheese placed in cold storage were scored the first time when about three months old, and again at intervals of one month. This plan was followed in the scoring of all the cheese in the cold storage experiments.

Average Score of the Cheese. (All cheese were scored 10 for finish.)

| Qualities. | Max. | A. | B. | C. | E. |
|---|---|---|---|---|---|
| Flavor | 40 | 35.77 | 36.34 | 36.15 | 32.18 |
| Closeness | 15 | 14.16 | 13.93 | 13.84 | 13.65 |
| Even Color | 15 | 14.56 | 14.61 | 14.61 | 13.75 |
| Texture | 20 | 17.96 | 18.00 | 18.00 | 16.00 |
| Finish. | 10 | 10.00 | 10.00 | 10.00 | 10.00 |
| Total | 100 | 92.45 | 92.88 | 92.60 | 85.58 |

It will be noticed that there is very little difference in the quality of the cheese, whether put directly into cold storage or placed there after one or two weeks in an ordinary ripening room. However, we need to bear in mind that 1902 was an exceptionally cool season, and the cheese held in the regular ripening room for two weeks did not deteriorate so much as they would likely do in a hot summer. In 1901 those cheese put directly into cold storage from the press stood first in quality. If it is more convenient to do so we should judge that placing cheese in cold storage once a week, from the factory ripening (curing) room would be quite satisfactory.

The E cheese ripened in the ordinary room were inferior in quality as compared with those in cold storage. These results agree with those obtained in 1901.

*2. Cheese moved from Cold Storage to Ripening Room.*

It has been claimed that if dairy goods are held for some time in cold storage, and then brought into a moderately warm temperature, they would deteriorate very rapidly. To test this point, from April 17th to November 12th, six lots of cheese were made, having five cheese in each lot—thirty cheese altogether. Four cheese in each lot were taken to the cold storage from the press, while the fifth was placed in an ordinary room and remained there. One of the four (A) remained in the cold storage, while the other three were taken to the ripening room—B at the end of one month, C in two months, and D in three months.

The A cheese which remained in the cold storage lost 2.04 per cent. in weight at the end of a month, the B cheese lost 2.18 per cent., the C cheese 2.18, the D 1.87, and the E, in the ordinary ripening room lost 4.24 per cent. in weight in one month.

Average Score of the Cheese. (All cheese scored ten for finish.)

| Qualities. | Max. | A. | B. | C. | D. | E. |
|---|---|---|---|---|---|---|
| Flavor.. | 40 | 36.80 | 35.46 | 36.04 | 36.39 | 33.69 |
| Closeness | 15 | 14.36 | 13.88 | 13.83 | 13.72 | 13.80 |
| Even Color | 15 | 14.56 | 14.46 | 14.45 | 14.83 | 13.80 |
| Texture | 20 | 18.00 | 17.15 | 17.29 | 17.59 | 16.30 |
| Finish.. | 10 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Total | 100 | 93.72 | 90.95 | 91.61 | 92.53 | 87.59 |

The cheese were scored about once a month during the season, after they became ripe enough to judge of their quality. The final scorings were made in April, 1903, hence there has been every opportunity to judge of the effects of moving cheese from cold storage to ordinary temperatures. The scorings show that the A cheese, which remained in the cold storage during the whole ripening period were first in quality, and the cheese range in order of merit from the date of moving them—the best cheese being those which remained in cold storage longest, although there was no marked deterioration in those moved to a warmer temperature. All the cheese which were ripened in cold storage from one to three months were better in quality than those in the ordinary room.

*3. Cheese Made with Extra Rennet and Ripened in Cold Storage.*

Eight lots of cheese, having four in each lot, were made between April 21st and September 8th. Each lot was made by using rennet at the rate of six ounces per 1,000 pounds milk instead of the usual quantity (three and a third ounces).

The A cheese were placed directly from the press in cold storage at an average temperature of 38.9 degrees. The B and C cheese were moved into cold storage at the end of one week and two weeks, while E remained in the ordinary room.

The percentage loss in weight in one month was respectively 2.37. 2.75, 3.20, and 3.86, on cheese weighing about 30 pounds each.
The average score of the cheese was as follows:

Average Score of the Cheese.

| Qualities. | Max. | A. | B. | C. | E. |
|---|---|---|---|---|---|
| Flavor | 40 | 36.70 | 26.70 | 36.20 | 33.30 |
| Closeness | 15 | 14.30 | 14.25 | 13.85 | 13.50 |
| Even Color | 15 | 14.80 | 14.67 | 14.60 | 14.60 |
| Texture | 20 | 18.65 | 18.27 | 18.10 | 17.70 |
| Finish | 10 | 10.00 | 10.00 | 10.00 | 10.00 |
| Total | 100 | 94.45 | 93.89 | 92.75 | 89.10 |

The scorings show that the cheese placed directly in cold storage were best in quality, and the other two lots range in quality according to the time of placing in cold storage—those put in at the end of a week being first and those at the end of two weeks being second, while those ripened in the ordinary room are poorest. In series one there was very little difference in the first three lots whether placed at once into cold storage, or whether placed at the end of one or two weeks. In this series with the larger quantity of rennet, those placed directly into cold storage scored considerably higher, and they are also higher in scoring than the average of either series 1 or 2.

*4. Cheese Made with Extra Rennet, Cooked to 94 Degrees and Salted Lightly.*

Twelve lots of cheese were made from May 20th to August 21st from milk containing an average of 3.71 per cent. fat. One-half the cheese were made in the usual way, and the other half were made by using from two and a half to six ounces of rennet per 1,000 pounds milk; the curds were cooked to 94 degrees, and they were salted one-half pound of salt less per 100 pounds curd. Both lots were ripened in an ordinary ripening room at an average temperature of 62 degrees, and a humidity of 80.2 per cent.

The other set of experiments belonging to this series, consisted of fourteen lots of cheese made between April 22nd and August 15th from milk averaging 3.73 per cent. of fat. They were made similar to the first set, i.e., one-half in the usual way and the other half by using more rennet, cooking at 94 degrees and using one-half pound less salt, but both lots were ripened in cold storage at an average temperature of 38.9 degrees, and 90 per cent. humidity.

Average Score of Cheese in Series 4.

| Qualities. | Max. | Ripened in ordinary room. | | Ripened in cold storage. | |
|---|---|---|---|---|---|
| | | Cheese made with extra rennet, etc. | Cheese made in ordinary way. | Cheese made with extra rennet, etc. | Cheese made in ordinary way. |
| Flavor | 40 | 34.50 | 34.50 | 35.76 | 36.29 |
| Closeness | 15 | 13.66 | 13.50 | 14.17 | 14.23 |
| Even color | 15 | 13.82 | 13.82 | 14.47 | 14.58 |
| Texture | 20 | 16.66 | 16.66 | 17.00 | 17.88 |
| Finish | 10 | 10.00 | 10.00 | 10.00 | 10.00 |
| Total | 100 | 88.64 | 88.48 | 91.40 | 92.98 |

The green cheese made by using an extra amount of rennet, cooking to a lower temperature and using less salt, produced an increase of 1.1 per cent. of ripened cheese when ripened in the ordinary room, and an increase of 2.4 per cent. when ripened in cold storage. The scorings show very little difference in the average quality of the cheese ripened in the ordinary room, which is different from the results obtained in previous years when such cheese were "acidy" and of inferior quality. The cool season may account for the difference in the results for 1902.

The other lots of cheese made from extra rennet, etc., and those made in the usual way, but ripened in the cold storage, were both superior in quality as shown by the scorings. However, the cheese made in the usual way scored somewhat higher, and we are not prepared to recommend cheesemakers to leave more moisture in the curds to increase the yeild of cheese ripened in cold storage, until we have further data. It is quite possible to increase the yield of cheese from one to two and a half per cent., but it would appear to be at the expense of quality, so far as we have light at present.

Further experiments made in 1903 indicate that the quality of the cheese was not injured by an increase of one to two per cent. moisture in the cheese ripened in mechanical cold storage, though it might be injured in an ice cold storage.

5. *Ordinary vs. Light-Salted Cheese Ripened in Cold Storage.*

In series 5 the object was to note the effect of using one-half pound less salt per 100 pounds curd, when cheese were ripened in cold storage. Between August 16th and October 11th, 1902, twelve lots of cheese were made. At the time of salting, the curds were equally divided, and six were salted at the rate of two and a quarter pounds of salt per 100 pounds curd, while the other six lots were salted at the rate of two and three-quarter pounds salt per 100 pounds curd. The cheese were made from milk averaging 3.85 per cent. fat, and averaged about 31 pounds in weight. There was a slight increase (about one-half a pound on 31 pounds. cheese) in the yield of the cheese by salting two and a quarter pounds per 100 pounds curd. The average total score was 93.78 for the cheese lightly salted and 94.46 for those salted in the usual way. There was a slight decrease in the yield of the cheese by the heavier salting, and an improvement in the quality.

6. *Boxing Green Cheese and Ripening in Cold Storage.*

This series was undertaken to obtain further data upon the practicability of placing cheese in a box directly from the press, or after remaining one week in an ordinary ripening room, instead of placing the cheese on shelves and turning them daily, which involves a great deal of labor.

Between July 2nd and November 5th, 1902, twenty-five cheese were made. Five were marked A, and were put directly from the press on a shelf in the cold storage and turned frequently. Five were marked B and also taken directly from the press to cold storage, but were put into boxes without turning. C and D were taken to the cold storage, after remaining a week in the ordinary ripening room, when the C's were placed on a shelf and turned, while the D's were put into a box and not turned. The E's remained in the ordinary ripening room.

The A's lost an average of 2.35 per cent. in weight during one month, while ripening, the B's 1.74, the C's 2.69, the D's 2.36 and the E's 4.67 per cent.

Average Score of the Cheese in Series 6.

| Qualities. | Max. | A. | B. | C. | D. | E. |
|---|---|---|---|---|---|---|
| Flavor | 40 | 37.05 | 37.65 | 37.40 | 37.50 | 35.28 |
| Closeness | 15 | 14.50 | 14.20 | 14.50 | 14.35 | 13.85 |
| Even color | 15 | 14.40 | 14.30 | 14.35 | 14.30 | 14.14 |
| Texture | 20 | 18.10 | 18.40 | 18.20 | 18.10 | 16.71 |
| Finish | 10 | 10.00 | 10.00 | 10.00 | 10.00 | 10.10 |
| Total | 100 | 94.05 | 94.55 | 94.45 | 94.25 | 89 98 |

The scorings show very little difference in the quality of the four lots of cheese. The B cheese which were put in boxes in cold storage directly from the hoops have the highest average score, while those ripened in the ordinary room are the lowest in the series as in all the others. The results indicate very forcibly that cheese may be put into a dry, clean, cheese box directly from the press, or after being one week in an ordinary ripening room, and then be put in cold storage at an average temperature of 38 to 40 degrees, and 90 per cent. humidity with very satisfactory results. These were the best cheese made during the season, and all those who judged them pronounced them "finest" goods. The large amount of mould which collected on the outside of the cheese in the box was the chief drawback. To overcome this a series of experiments with formalin were made.

*7. Formalin Sprayed on the Cheese to Prevent Mould.*

Cheese made April 22nd, 29th, May 6th and May 27th, which had as nearly as possible an equal quantity of mould on each, were put into boxes. One-half were sprayed with formalin, and the other were not sprayed. When examined on August 26th those not sprayed were found to be very mouldy, while those which had been sprayed on the ends of the cheese and very lightly in the box, and on the scale boards were quite free from mould. Other cheese put directly from the press into boxes in cold storage and sprayed with formalin were equally free from mould. This plan would seem to be a preventive of mould, but owing to the strong nature of the formalin, not many cheese could be treated at one time by the same person, and the expense would be considerable with a large number of cheese. Some better remedy will doubtless be found.

*8. Paraffining Cheese.*

Experiments were continued during 1902 with dipping cheese into paraffine wax at a temperature of about 180 degrees. The cheese were dipped at stages, directly from the press, at the end of one week, two weeks and three weeks.

The best results, in appearance, were got by dipping the cheese in hot wax about one week after they were made, and then placing the cheese in cold storage. For cheese ripened in an ordinary room, we can see no particular advantage in paraffining cheese. It tends to prevent the growth of mould, and prevents loss of weight while ripening. Recent reports from England say that the cheese which have been paraffined have not been well received on the markets of Great Britain. The chief advantage seems to be to prevent loss of weight while the cheese are held. It will probably pay the speculator to have the cheese coated, but it is a question whether it will pay the average factoryman to dip his cheese in paraffine wax at the present time.

Average Score of the Cheese in Paraffining Experiments.

| Cheese. When made. | Cheese. Paraffined. | Average flavor. Max. 40. | Average closeness. Max. 15. | Average color. Max. 15. | Average texture. Max. 20. | Average total. Max. 100. |
|---|---|---|---|---|---|---|
| Aug. 18........ | From press..... | 36.94 | 13.94 | 13.61 | 17.44 | 91.94 |
| Sept. 1 and Sept. 22. Ripened in cold storage.. | Not paraffined.. | 37.00 | 13.94 | 13.77 | 17.44 | 92.16 |
| Oct. 6 and 13.... | From press..... | 35.75 | 13.25 | 13.87 | 17.12 | 90.00 |
| | 1 week....... | 36.37 | 13.00 | 13.50 | 17.12 | 90.00 |
| | 2 weeks....... | 36.87 | 13.50 | 13.62 | 17.62 | 91.62 |
| | 3 weeks....... | 37.25 | 13.62 | 13.87 | 17.37 | 92.12 |
| Ripened in ordinary room. ... | Not paraffined.. | 37.00 | 13.75 | 14.00 | 17.62 | 92.37 |

The cheese made during August and September were scored on November 22nd, 1902, and January 1 and April 14th, 1903, by Mr. G. H. Barr, as were also those made in October. The cheese not paraffined averaged slightly higher in quality, when full points were given for finish as in the other series. Taking appearance or finish into account, they scored lower. The average of three scorings for appearance on three lots of paraffined cheese made during August and September ripened in cold storage was 6.33 out of a possible ten, while the lots not paraffined averaged 3.55 points.

The October lots not paraffined also scored slightly higher when giving full points for finish. Taking appearance into account they scored an average of 6.5 points out of a possible ten. Those dipped at the end of three weeks scored 7.5, those paraffined in two weeks 8.0, those in one week scored 9.25, and those dipped in paraffine wax directly from the press scored an average of 8.75.

The chief gain was in the saving of shrinkage. The paraffined cheese lost no more than the weight of the wax which adheres to the cheese. Those dipped in one week lost .78 per cent., in two weeks 1.57 per cent., three weeks 2.36 per cent., and those not coated lost 3.16 per cent. in one month. The cheese weighed an average of about 30 pounds each.

### Acidity of the Milk and Curd.

The acidity of the milk at the time of adding the rennet varied from .2 on June 9th to .23 on July 21st and September 8th. It averaged .216 for the sea-

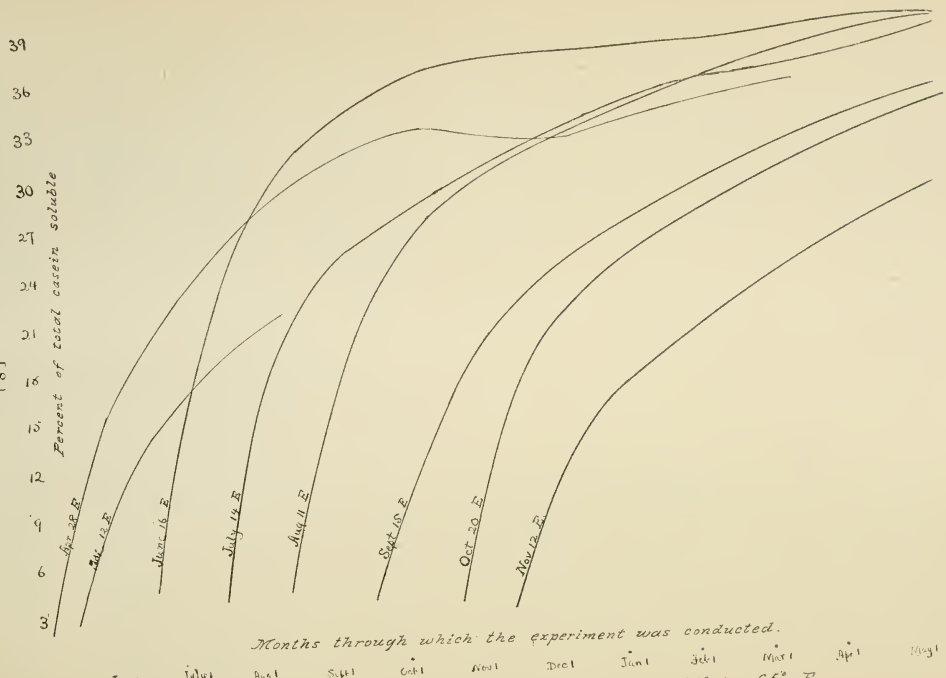


Diagram Illustrating Rate of Ripening at 60° to 65° F.

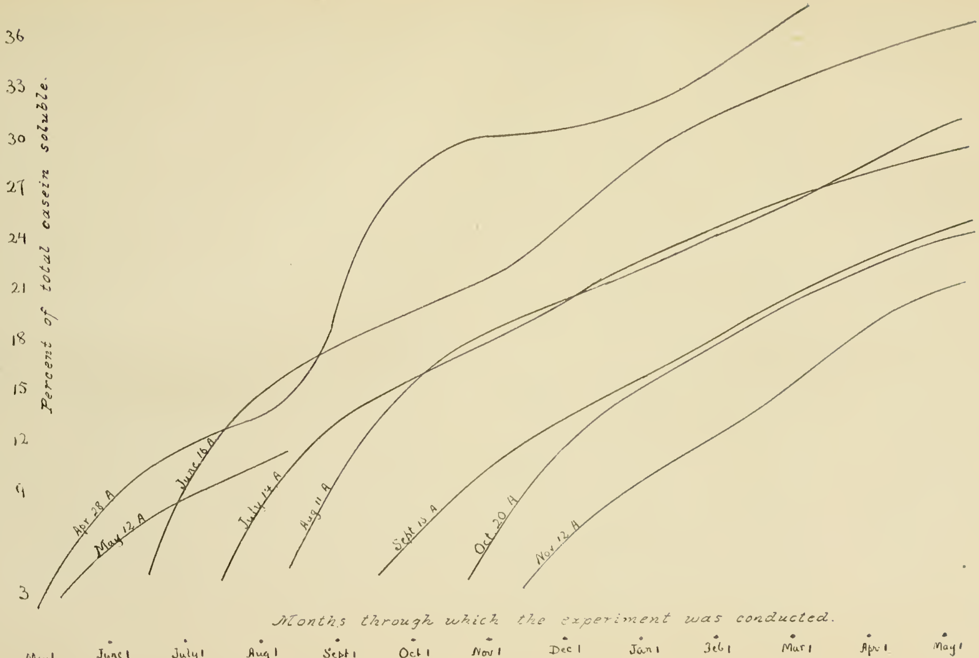


Diagram Illustrating Rate of Ripening at 40° F.

son. At dipping, the curd ranged from .18 to .23 and averaged .198 for the season. When the curds were milled the acidity varied from .69 to .9 and averaged .806. At the time of salting, the acidity varied from .85 to 1.14 and averaged 1.005 for the season.

In our cheese work at the Dairy department of the College, we have practically discarded the rennet and hot iron tests, as the acidimeter is more convenient, less wasteful of material, and much more accurate in its results.

### White Specks in Cheese.

No white specks were noticed in the cheese ripened in cold storage in 1902. The only explanation we can offer is that the cheese were not allowed to go below freezing point in the winter of 1902 and 1903, whereas in the winter of 1901 and 1902 the cheese were below freezing point, and the white specks were quite pronounced in the cheese.

The general conclusions of Drs. Babcock and Russell of Wisconsin on this question are:

"The chief factors determining the formation of white specks in cheddar cheese seems to be that of temperature and salt. Low temperatures favor very much the production of these specks. Rarely do they appear at 60 degrees Fah., except where other conditions are peculiarly favorable for their production."

"The addition of salt tends to prevent their formation under all conditions. Also they are not so apparent when increased quantities of rennet are used. They are especially abundant in skim cheese, but do not appear in very rich cheese even at low temperatures. In sweet curd cheese no specks were found at any temperature."

### The Effect of Temperature on the Rate of Ripening of Cheese.

There is every reason to believe that the ripening of cheese depends on the growth and chemical changes produced by ferments. Just what are the best conditions under which these ferments work is not definitely known, nor are the chemical changes that take place fully understood. It has been proved, however, that cheese will ripen more slowly, and will develop a milder, cleaner flavor and better texture at a temperature of 40 degrees Fah. than at 60 degrees Fah. All the chemical changes which take place within the cheese during the ripening process have not been studied out; but it is known that one of the most important is the changing of the insoluble casein into soluble compounds. These changes apparently take place much more slowly, especially in the early stages of ripening, at the lower temperature. In order to study the amount of casein rendered soluble and the comparative rate at which these changes take place under the two different conditions of ripening, a large number of analyses of cheese were made from month to month in 1901 and again in 1902. The cheese used in this work were marked A and E in series 1 of this bulletin, and cheese made and ripened under similar conditions in 1902, also marked A and E*. In both year's experiments the A cheese were placed at once in cold storage, the average temperature of which for the season was 38.9 degrees Fah., and E in ordinary ripening room, where the average temperature was 62 degrees Fah. An endeavor was made to determine the total amount of nitrogenous matter, or casein, the amount of casein soluble in

*See Bulletin 121, Ontario Agricultural College. Ripening of Cheese in Cold Storage Compared with Ripening in Ordinary Curing Room.

water, and the amount of ammonia, which is the end product in the decomposition of the casein, in A and E cheese for each month from April to November. With the exception of September, a monthly analysis was also made of each cheese made in 1902 from date of making to May, 1903. The analyses were not made so regularly in 1901, but enough was done to show the amount of casein rendered soluble monthly during a period of eleven months.

## Notes on Methods of Analyses.

Sampling. In taking the sample for analysis, two plugs were drawn from opposite sides of the cheese by means of an ordinary cheese tryer and bottled at once. The sample was then chopped up fine inside the bottle with a thin spatula, well mixed, and tightly corked up. From this portions were taken for analysis.

Total Nitrogenous Matter, (principally casein). The nitrogen as determined by the Kjeldahl process, was multiplied by 6.25 to obtain nitrogenous matters.

Water Soluble Nitrogenous Water. Ten grams of cheese were ground in a porcelain mortar with sharp clean sand, transferred to a flask, treated with from 75 to 100 cc. of cold distilled water, and warmed in a water bath to 60 to 65 degrees C. as soon as possible. After reaching this temperature and after thorough stirring the liquid was poured on a pad of cotton wool in a glass funnel and filtered into a 500 cc. flask. Another portion of water at about 60 degrees C. was then poured on the sand and cheese, and the flask containing them replaced in a water bath at 60 to 65 degrees C. This operation was repeated six or seven times, with frequent stirrings, the water remaining in contact with the cheese from 15 to 30 minutes. Each extraction occupied from two to three hours. The cheese extract thus obtained was cooled and made up to a volume of 500 cc., and then filtered under pressure through a thick pad of asbestos. The nitrogenous matter soluble in water was then obtained by determining the nitrogen in an aliquot portion of the extract by the Kjeldahl process, and multiplying it by the factor 6.25.

Ammonia was determined in the original cheese by grinding a suitable quantity (usually 10 grams) with cold water in a porcelain mortar, transferring to a distillation flask, making alkaline with magnesium oxide ($MgO$) and distilling off the ammonia.

It is not, strictly speaking, correct to use the term "casein" when the total nitrogenous matter is meant; yet, as casein is the principal nitrogenous constituent of new cheese and the one best known to dairymen, it will be used in that sense in the discussion of results hereafter given.

## Rate at which Casein is Changed to Soluble Compounds.

The following table gives the average percentage of total casein in A and E cheese found soluble in water at the end of one, two, three, and up to eleven months. The figures do not represent the rate at which the casein in any one pair of cheese became soluble; but the average of all cheese for the season when one, two, three, etc., months old. The percentage of total casein changed to ammonia for the same periods is also given. These figures, therefore, represent the averages obtained from cheese one or more months from date of making at all seasons of the cheese-making year.

The average percentage amount of total casein changed to soluble and ammonium compounds per month for 1901 and 1902.

| Age of Cheese. | 1901. A. Per cent. of total casein changed to soluble compounds | 1901. A. Per cent. of total casein changed to ammonium compounds. | 1901. E. Per cent. of total casein changed to soluble compounds | 1901. E. Per cent. of total casein changed to ammonium compounds. | 1902. A. Per cent. of total casein changed to soluble compounds | 1902. A. Per cent. of total casein changed to ammonium compounds. | 1902. E. Per cent. of total casein changed to soluble compounds | 1902. E. Per cent. of total casein changed to ammonium compounds. |
|---|---|---|---|---|---|---|---|---|
| 1 month. | 9.7 | ........ | 17.7 | .75 | 9.9 | ........... | 17.6 | 1.5 |
| 2 months | 14.6 | .......... | 25.3 | 1.2 | 12.6 | .......... | 23.1 | 2.2 |
| 3 " | 15.4 | .5 | 26.3 | ......... | 15.1 | 1.5 | 24.7 | 2.3 |
| 4 " | 16.9 | ......... | 28.2 | .......... | 17.8 | 1.5 | 29.8 | 3.1 |
| 5 " | 18.2 | .7 | 30.0 | 1.8 | 21.3 | 2.0 | 32.1 | 3.5 |
| 6 " | 20.6 | .8 | 32.5 | 2.5 | 22.4 | 2.1 | 33.1 | 3.4 |
| 7 " | ...... | ........... | .... | .......... | 24.3 | 2.7 | 34.9 | 3.9 |
| 8 " | 26.9 | 2.3 | 37.5 | 3.5 | 27.3 | 2.6 | 36.8 | 4.2 |
| 9 " | 26.5 | 1.5 | 37.1 | 4.2 | 29.1 | 2.8 | 38.1 | 4.4 |
| 10 " | 28.2 | 2.8 | 38.3 | 4.5 | 29.0 | 3.0 | 38.7 | 4.6 |
| 11 " | 32.9 | 2.8 | 40.6 | 5.0 | ..... | .......... | ...... | .......... |
| Average monthly gain after 1 month. | 2.26 | .......... | 2.33 | .......... | 2.13 | .......... | 2.34 | .......... |
| Average monthly gain after 2 months. | 1.97 | .......... | 1.74 | .......... | 2.06 | .......... | 1.95 | ......... |

Two points are particularly noticeable in this table. First, the E cheese contained at any given time more soluble compounds than the A cheese; and, second, the E's made most of their gain in solubility over the A's during the first month. Looking at the average monthly increases in solubility from the time the cheese were one month old given at the bottom of the table, it will be seen that in both years' work the E cheese gained a little faster than the A's; but that taking an average of the increases from two months on, the E's did not gain so rapidly as the A's. The casein of the E cheese was broken down a little more quickly during the second month than that of the A's; yet it is evident that the cheese ripened at the higher temperature made the most of their gain over those in cold storage during the first month and that from that time on they ripened fairly evenly. If we measure the ripeness of the cheese by the breaking down of the insoluble casein as shown by the percentage amount soluble the cheese kept at a temperature of from 60 to 65 degrees Fah. are as ripe at the end of one month as those kept at about 40 degrees Fah. are at the end of four months.

It appears as though the amount of ammonium compounds formed is somewhat proportional to the casein rendered soluble.

The percentage amount of total casein soluble in the different pairs of cheese at the time of the monthly analysis is given in the following table. The first column gives the date of making and the succeeding ones the conditions of the casein immediately on taking from the press and at one, two, and up to eleven months from that time.

Percentage amount of total casein soluble in water at stated intervals in cheese made in 1902.

| Date of Manufacture. | 1 day. | Number of months from date of making. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| April A.. | ...... | 8.0 | 11.4 | ..... | 15.4* | ...... | 31.2 | 28.1 | 31.1 | 31.6 | 36.7 | .... |
| 28th E.. | ... | 15.5 | 22.8 | ..... | 29.2 | ...... | 33.0 | 30.7 | 32.3 | 33.8 | 37 3 | .... |
| May A.. | 2.7 | 7.4 | 9.2 | 11.2 | Discarded on account of development of a bad flavor. | | | | | | | |
| 12th E.. | 2.7 | 14.1 | 17.9 | 21 8 | | | | | | | | |
| June A.. | 4.0 | 13.5 | 16.3 | ...... | 21.6 | 21.6* | 29.2 | 28.5 | 32 4 | 34.1 | 34.8 | 36.6 |
| 16th E.. | 4.0 | 22.7 | 31.8 | .... | 36.5 | 37.9 | 37.1 | 37.2 | 38.9 | 38.1 | 40.5 | 39.5 |
| July A.. | 3.7 | 12.1 | ...... | 16.5 | 18.1 | 21.9 | 22.3 | 26.2 | 26 4 | 27.7 | 29.0 | .... |
| 14th E.. | 3.7 | 22.1 | ..... | 28.9 | 30.1 | 33.7 | 34.7 | 35.8 | 36.7 | 37.0 | 38.7 | .... |
| Aug. A.. | 4.3 | .. | 17.4 | 18.5 | 20.6 | 23.1 | 25.3 | 24.8 | 31.1 | 30.5 | ..... | .... |
| 11th E.. | 4.3 | ...... | 28.8 | 29.7 | 32.5 | 34.1 | 37.9 | 35.8 | 38.8 | 39.2 | ...... | .... |
| Sept. A.. | ..... | 9.7 | 11.1 | 16.1 | 15.3 | 20.1 | 21.7 | 23 5 | 24.6 | ..... | .... | .... |
| 15th E. | ...... | 16.6 | 22 0 | 21.1 | 28.2 | 30 9 | 32.1 | 33.7 | 35.0 | ...... | .. .. | .... |
| Oct. A.. | 3.6 | 10.5 | 13.7 | 15.7 | 19.6 | 20.3 | 24.3 | 22.9 | ...... | ..... | ...... | .... |
| 20th E.. | 3.6 | 18.0 | 21.3 | 25.5 | 29.2 | 29.7 | 32 2 | 34.3 | .... | ..... | ...... | .... |
| Nov. A.. | ..... | 8.2 | 9.3 | 12.5 | 16.2 | 20.5 | 18.5 | ... . | . .. | .... | .... | .... |
| 12th E.. | ..... | 14.0 | 17.2 | 21.5 | 22.6 | 26.2 | 28.8 | ...... | ..... | ...... | ...... | .... |

* A and E cheese reversed at this point.

Here again it is evident that the casein of both cheese of each month was changed to a soluble form faster during the first month than during succeeding months and that the casein of E cheese became soluble much more rapidly than A. This is also true, although the development was slower, in the second month; but from that time on the cold storage cheese seemed to ripen as rapidly as those at the higher temperature. As the most rapid gain of the E's over A's is not so great during the second month, it is possible that the first six weeks covers the time during which the former ripens faster than the latter.

Another point worthy of notice in this table is that the cheese made in June, July, and August contained a larger amount of soluble compounds at the time of taking from the press than those made in the spring and fall. They also gained in solubility, or ripened, much faster than those made in other months. This applies to those kept in cold storage as well as to those kept in the ordinary ripening room, and is doubtless due to the difference in the condition of the milk, or its germ content, at that season of the year; for, the milk was brought to the same degree of acidity before adding the rennet and treated the same throughout the after process in all the different experiments.

When the April cheese were four months old, or in August, the A and E cheese were reversed; that is, A was taken out of cold storage and placed in the ordinary ripening room at a temperature of 60 to 65 degrees Fah., while E was taken from this latter room and placed in cold storage. Notice the very rapid gain in the amount of casein soluble from the fourth to the sixth months in A. while the rate of change in E became slower. The June cheese were reversed in November and the same changs are noticeable. Why the results should be lower in some instances than they were in the preceding month, as, for example, the sixth and seventh months of April cheese, cannot be explained, unless it is due to errors in sampling. As cheese is a mixture of substances, no assurance can be given that the two plugs taken as a sample always accurately represented the whole cheese. Yet larger samples could not very well be taken when the analyses were to be continued for a number of months. At the same time, the monthly analyses probably give results which fairly well represent the changes in the solubility taking place during the ripening process.

The curved lines in the accompanying diagrams graphically represent the rate at which casein changed to soluble compounds in the cold storage cheese as compared with those ripened at the higher temperature. Notice how much more perpendicular the first part of the lines representing E cheese are than those representing A cheese. It will be remembered that April cheese were reversed in August; notice the abrupt upward curve of the line representing A cheese at this point. June cheese were reversed in November, but the upward curve following the change is not so pronounced as in the preceding case. Possibly this is due to the casein being at a more advanced stage of decomposition when the cheese were changed. Another noticeable point is the similarity in the rate of ripening of July and August cheese under A and E conditions. The same may be said of September and October.

The quality of the cheese under the two methods of ripening has been dealt with on page 2 of this bulletin; but for purpose of comparison, the total scores and the time at which they were made are given in the following table:

Total scores at several different dates.

| Date of Manufacture. | Number of months from date of making. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| April A | .... | .... | 89 0 | .... * | .... | .... | .... | 85.0 | .... | .... | .... |
| 28th E | .... | .... | 85.0 | 84.0 | .... | 89.0 | .... | 83.0 | .... | .... | .... |
| May A | .... | 83.0 | 77.0 | .... | 77.0 | .... | .... | .... | .... | .... | .... |
| 12th E | .... | 79.0 | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| June A | .... | .... | .... | 93.0 | 94.0* | 95.0 | .... | .... | .... | 87.0 | 89.0 |
| 16th E | .... | 85.0 | .... | 91.0 | .... | 87.0 | .... | .... | .... | .... | 85.0 |
| July A | .... | .... | 95.0 | .... | 96.0 | .... | 92.0 | .... | .... | 95.0 | .... |
| 14th E | .... | .... | 92.0 | .... | 89.0 | .... | .... | .... | 85.5 | 86.0 | .... |
| Aug. A | .... | .... | .... | .... | .... | 92.0 | .... | 93.5 | 99.0 | .... | .... |
| 11th E | .... | 90.0 | .... | 85.0 | .... | .... | .... | .... | 84.0 | .... | .... |
| Sept. A | .... | .... | .... | .... | 91.5 | .... | 96.0 | 95.0 | .... | .... | .... |
| 15th E | .... | 91.0 | 84.0 | .... | .... | .... | 81.0 | 73.0 | .... | .... | .... |
| Oct. A | .... | .... | .... | 92.5 | .... | 96.0 | 98.0 | .... | .... | .... | .... |
| 20th E | 89.0 | 86.0 | .... | .... | .... | 90.0 | 91.0 | .... | .... | .... | .... |
| Nov. A | .... | .... | 96.0 | .... | 93.5 | 96.0 | .... | .... | .... | .... | .... |
| 12th E | 89.0 | .... | .... | .... | 88.0 | 88.0 | .... | .... | .... | .... | .... |

* A and E cheese were reversed at this point.

Unfortunately, the scoring was not followed regularly on the April and June cheese after the A's and E's were reversed. The score indicates that the cheese kept in cold storage have a much longer commercial life than those ripened at a higher temperature.

## The Influence of Salt on Cheese.

In some investigation work done by Mr. H. Rive, B.S.A., in connection with his graduation thesis, the cheese made as outlined in series 5 of this bulletin, were analyzed. From the results he obtained, the percentage of salt, moisture, and total casein soluble, as affected by the two quantities of salt used, are selected. The twelve cheese were examined twice—once when they were two, three, and four months old, and again when five, six, and seven months old. The results reported under two and five, three and six, four and seven months are from the same cheese; and as there were two pairs of cheese each month, each result is an average obtained from two cheese. The following are the results:

Effect of different quantities of salt on the amount of moisture and salt retained, and on the rate of decomposition of the casein of cheese.

| Age of cheese. | Per cent. of salt retained when curd was salted at the rate of | | Per cent. of water retained when curd was salted at the rate of | | Per cent. amount of total casein changed soluble compounds, salted. | |
|---|---|---|---|---|---|---|
| | 2.25 lbs. per 100 lbs. curd. | 2.75 lbs. per 100 lbs. curd. | 2.25 lbs. per 100 lbs. curd. | 2.75 lbs. per 100 lbs. curd. | 2.25 lbs. per 100 lbs. curd. | 2.75 lbs. per 100 lbs. curd. |
| 2 ..... | ............ | ........... | ............ | ............ | 12.5 | 11.6 |
| 3 ..... | ...... .... | ..... ...... | ............ | .......... | 22.2 | 20.3 |
| 4 ...... | ............ | ............ | ............ | ............ | 21.6 | 20.2 |
| 5 ...... | 1.50 | 1.64 | 33.97 | 33.19 | 23.2 | 21.9 |
| 6 ...... | 1.72 | 1.92 | 34.01 | 32.88 | 27.5 | 26.5 |
| 7 ..... | 1.75 | 1.98 | 33.83 | 33.25 | 26.0 * | 24.0 * |
| Average.... | 1.66 | 1.84 | 33.91 | 32.10 | ...... .... | ............ |

* From one cheese only.

According to these results, one-half pound more salt decreased the amount of moisture by nearly one per cent. It also retarded the rate at which casein was changed to soluble compounds. The amount of salt retained in ripe cheese is not in proportion to the quantity added. If the heavier salted cheese retained salt at the same rate as the lighter salted ones, they would have contained 2.03 per cent. instead of 1.84. Two years ago Dr. Van Slyke, New York State Experiment Station, Geneva, drew attention to results similar to those just given*. His experiments were conducted with cheese ripened at 70 degrees Fah., while those used in this experiment were ripened at a temperature of 40 degrees Fah.

### Conclusions.

1. The cheese ripened in cold storage at a temperature of about 38 degrees were much superior in quality to those ripened in an ordinary ripening room at a temperature of about 62 degrees. The chief improvement is in flavor and texture. The cheese ripened in cold storage have a mild, clean flavor and silky texture, while those ripened in the usual way were more liable to be "off flavor" and "mealy" in texture, especially when from three to six months old, at which time those ripened in cold storage are beginning to get in good condition for eating. These results correspond with those obtained in 1901.

2. If we measure the ripeness of the cheese by the amount of casein changed to compounds soluble in water, the cheese kept at the higher temperature were as ripe at the end of one month as those kept at a lower temperature were at the end of four months.

3. The cheese placed in the ordinary ripening room ripened much faster during the first month, a little faster during the second month, but more slowly during the succeeding months than those placed in cold storage.

*Report of Ontario Dairymen's Association for 1901.

4. The cheese made in the months of June, July, and August ripened faster, both in the ordinary ripening room and in cold storage, than those made in the spring and fall months.

5. The cheese which were ripened in cold storage for periods of one to three months and then moved to an ordinary room, did not deteriorate rapidly after moving, but those allowed to remain in cold storage for the longest period were the best in quality. So far as those experiments indicate there is no risk in moving cheese, which has been ripened in cold storage, to an ordinary temperature for a reasonable length of time.

6. When cheese were removed from cold storage and placed in the ordinary ripening room the rate at which casein was decomposed increased, while, when the change was made in the opposite direction, apparently the reverse was true.

7. An extra quantity of rennet used in making some of the cheese placed in cold storage appeared to improve the quality as compared with cheese made in the other series, although no direct experiments on this point were made in 1902. The results also indicate that if a large quantity of rennet be used, the cheese should be placed in cold storage soon after being made in order to obtain the best results.

8. An increased yield of cheese equal to one or two per cent. may be obtained by using an extra quantity of rennet, and by cooking to 94 degrees, and by salting lightly, but the quality of the cheese made in this way in 1902 were not so good as those of 1901. At present we do not recommend cheese makers to try to leave more moisture than usual in the curd where cheese are to be placed in ice cold storage, though later experiments indicate that it may be all right for cheese ripened in mechanical cold storage.

9. From the results obtained during the past two years it would appear to be quite feasible to place cheese boxes in cold storage either directly from the press or after remaining a week on the shelves. This plan means a great saving in labor, and a saving of shelf room. The chief drawback is the growth of the mould on the cheese. This can be overcome to a large extent by spraying formalin on the cheese and in the boxes. The boxes should be clean and dry.

10. Dipping the cheese in paraffine wax at a temperature of 180 degrees makes a light coating over them, which prevents loss of weight while ripening or when held in cold storage. It also tends to prevent the growth of mould, and to some extent improves the appearance of the cheese, especially when placed in cold storage. So far as our work has gone we are not prepared to recommend the general paraffining of cheese to the ordinary factoryman. If the cheese are acceptable to British buyers, it would seem that the speculator in cheese is the person who would receive most profit from the process.

11. No "white specks" were noticed in the cold storage cheese of 1902, which we attribute to the fact that the cheese were not allowed to go below 32 degrees Fah. as they did in 1901, when the "white specks" were observed.

12. The amount of salt retained in cheese was not in proportion to the amount added.

13. When curd was salted at the rate of 2.75 pounds of salt per 100 pounds of curd, there was less water in the cheese, and the rate at which casein was changed was slower than when 2.25 pounds of salt were used.

14. Cheese ripened at a low temperature ripened more slowly during the first month or six weeks than those kept at a higher temperature; but after this period one ripens as fast as the other.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 132.

# ROUP:

## AN EXPERIMENTAL STUDY.

BY

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AND

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Ontario Agricultural College and Experimental Farm

# ROUP: AN EXPERIMENTAL STUDY.

Prof. F. C. Harrison and Dr. H. Streit, Bacteriological Department.

One of the most important poultry diseases in America is fowl diphtheria, more often called "Roup." It is very widespread ; but it is more prevalent in some places than in others; thus, for example, it is said to be almost unknown in the Canadian Maritime Provinces and in Eastern Ontario, while in Southern Ontario it is the most prevalent disease of fowls.

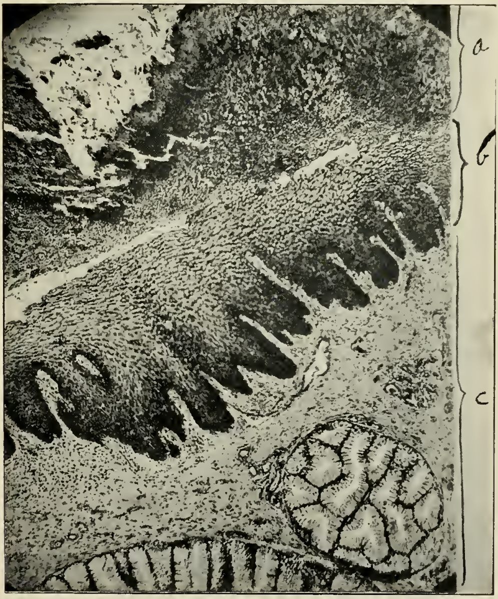



Fig. 1.—A section of false membrane of roupy fowl (No. 9). *a*. The false membrane partly separated from the middle epithelial layer. *b*. *c*. Submucosa. *d* Normal mucous glands.

The views of poultry raisers as to the origin of roup differ very much. A small number trace it to a neglected case of ordinary cold or catarrh, basing their belief on the fact that among fowls living under hygienic conditions, where even common colds receive prompt attention, roup is quite unknown ; but by far the greater number of breeders consider roup a more or less infectious disease, which is said to be produced by a certain micro-organism. This view is strengthened by accounts of the disease in the literature of poultry breeders, according to which epidemics have been caused by diseased fowls being brought into healthy flocks.

There is also an impression among poultrymen that fowls that have once overcome the disease possess a certain degree of immunity.

In America, V. A. Moore is the only person who has examined roup scientifically. The results of his investigations, however, are insufficient to establish the etiology of roup, and hence the need of further research.

For several years in succession roup has made its appearance in the poultry yards of the Ontario Agricultural College, usually during the cold, damp weather of late autumn and early winter. It usually causes a direct loss of from 10 to 15 per cent., and a much larger indirect one from the disease becoming chronic. It often lasts for months, and makes the fowls attacked absolutely worthless either for table use or for breeding ; and the most valuable fowls of the special breeds are the ones most frequently attacked by the disease. Young birds, six months or a year old, are particularly susceptible.

## Clinical Symptoms.

In the majority of cases, the first symptoms of roup appear in the nostrils. Moore found the disease most frequently localized in the eyes ; while, according to the statements in German, Italian, and French literature, the mouth, pharynx, nostrils, and wind-pipe are the places in which the first symptoms of the disease usually appear.

Over 300 cases of the disease have been studied at this institution. Thirty-six of the most severe were examined daily for several months. Of these, four recovered ; and the others died, or were killed for dissection.

## Nose.

Nose. Roup usually appears first in weak fowls as catarrh of the nose. At one or both nostrils a serous fluid is observed. Occasionally on a cold night in autumn or early winter a large part of the flock is suddenly attacked by catarrh ; and next morning as many as three-fourths of the fowls show a serous nasal discharge. In from three to eight days many fowls under normal conditions recover from this catarrh, without any further result. In others, however, both the general and local conditions grow worse, and develop through all the different stages of roup.

The serous nasal secretion soon becomes streaked with grey ; a slimy matter forms and dries quickly to dirty crusts, which often completely close the nostrils. The secretion never becomes yellow, as, according to Zuern and Friedberger-Froehner, is said to be the case in European fowl diphtheria.

On the removal of the crusts around the nostrils, a few drops of grey secretion flow out. These can be increased by pressing the nostrils. In later stages, small, solid, yellowish-white particles of matter are often found in the grey nasal secretion. The secretion decomposes and emits an offensive odor. On the mucous membrane of the nostrils, small cancers form ; or the whole nostril is completely filled with a firm, whitish-yellow cheese-like mass, which frequently grows very rapidly and separates the nostrils and forces the dorsal wall of the nostrils upward. This mass soon becomes dry and brown on the outside ; and it adheres quite firmly to the mucous membrane. If it is removed, it quickly forms again.

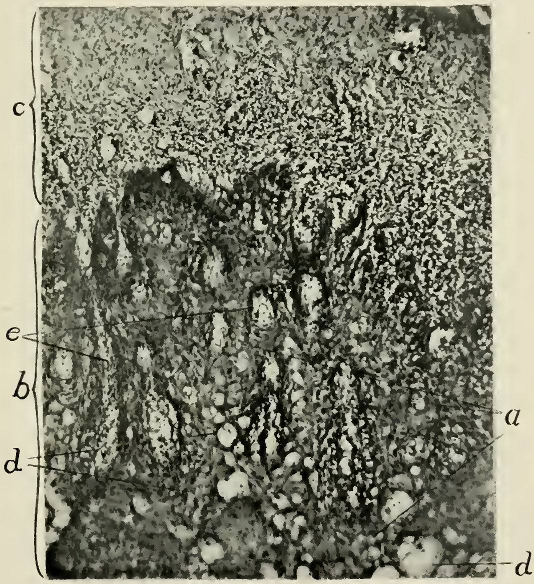



Fig. 2.—A section through the deeper epithelial layer under a firmly attached false membrane. *a*. Swollen epithelial nuceli. *b*. Epithelial layers dislodged from their normal position. *c*. Submucosa infiltrated by leucocytes. *d*. Homogeneous fibrinous exudate. *e*. Mixed fibrinous and purulent exudate.

As the changes above described progress, it becomes impossible for the bird to breathe through the nostrils, and the beak is kept open for breathing. In the early stages of the catarrh, the irritation causes sneezing ; but later this symptom disappears.

## Eyes.

From the diseased mucous membrane of the nostrils, the inflammation easily spreads to the mucous membrane of the mouth, pharynx, and larynx; yet, these parts may be the first seat of the infection. When the disease affects the eyes, there is often formed in the inner corner of the eye a viscous, lacrymal secretion, which contains air-bubbles. These bubbles come from the nose, and are forced into the eye through the lacrymal duct, because the natural air-passage through the nostrils is half stopped up and the air finds this outlet.

Soon a serous Conjunctivitis forms. The Conjunctiva becomes very moist, swollen and grey. The secretion gradually assumes a slimy, purulent condition. The lids well oedematously, and become perceptibly thicker in a single night. They are hot, sore, very much inflammed, and stick together very easily, because the eye at this stage of the disease is, for the most part, kept shut. Often the lacrymal duct remains open, and the secretion passes out into the nasal or pharyngeal cavity. In all the more severe cases, however, this canal is completely closed. The accumulating secretion frequently overflows into the inner corner of the eye, and defiles the surrounding region with greasy crusts of dried secretion. The small feathers on the side of the head stick together, and often fall out. When the lids stick together, they are forced outwards by the masses of secretion formed under the eye. The secretion consists of a somewhat thin, clear, or turbid fluid, containing jelly-like lumps, which are clear or striped with grey. The gelatinous masses are formed by a homogenous, or lightly striped, unstainable substance, mingled with pus corpuscles, epithelial cells, and bacteria. The grey parts are much richer in leucocytes than the clearer ones. The epithelial cells ars ciliated, with or without a swollen unstainable nucleus. The free epithelial nuclei are usually very much swollen (as large as 16m.m.m.), round, homogenous, or slightly granular and unstainable. In the centre of the nucleus there may be found one or two small, round bodies which can be stained.

If the secretion is left in the closed eye-lid, it may be completely changed in 24-48 hours to a firm, smooth, yellowish-white, cheese-like body, which fills up the whole eye-lid, and lies like a cap over the bulbus oculi. This cheesy mass may become so large that it forces the lids open, and projects between them. The outside then dries and becomes a brownish crust. Moore explains the formation of these cheesy masses by assuming that the liquid content of the eye-lid undergoes coagulation ; but, as stated above, they (the cheesy masses) are formed from jelly-like masses in the eye-lid. In all probability, the secretion is an abnormal product of the lacrymal glands and conjunctiva, and contains epithelial cells, as well as free swollen epithelial nuclei.

The grey spots of these gelatinous masses contain very many round cells. The greyer, firmer, and more turbid this mass becomes, the more numerous are the cells. When the mass finally assumes the cheese-like appearance, it consists of leucocytes, granular detritus, epithelial particles, and bacteria. The yellow cheese-like masses are produced by the pus corpuscles exuding in large numbers on to the surface of the mucous membrane, where they stick together, mix with the pathologic secretions, and probably with coagulable plasm. If the gelatinous masses are removed from the eye-lid and allowed to dry, they become a dirty, grey crust.

It is astonishing with what rapidity cheesy masses that have been removed form again. Thus, from hen 11, cheesy masses, the size of marbles, were removed from the same eye on three successive days. These solid masses can be easily removed ; but they may sometimes adhere to a croupous membrane on the mucosa.

In the further course of the Conjunctivitis, small croupous membranes appear on the Conjunctiva, and on the swollen lids, or the mucous membranes. These usually adhere closely ; and, on their removal, the mucous membrane begins to bleed.

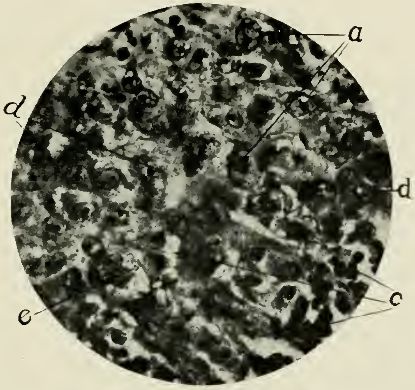



Fig. 3.—Section through the deeper epithelial layer under a firmly attached false membrane from hen No. 9, magnification 700. *a*. Swollen epithelial nuceli with 1 or 2 well-stained nucleoli. *b*. Nucleus of normal size granular staining. *c*. Leucocytes and fibrinous exudate. *d*. Granular detritus. *e*. Two short bacteria.

The Cornea may also become a direct seat of the disease, in which case small croupous membranes form on it. These may remain on the Cornea, or spread over the Conjunctiva of the bulbus oculi. Often the membrane grows through the whole Cornea. If it falls off, the interior eye cavity is either directly opened, or the remaining layer of the diseased Cornea is too thin to resist any following perforation. After the opening of the eye-cavity, a prolapse of the lens may occur ; and following this, a purulent ophthalmia develops. After the destruction of one eye, the other usually becomes sympathetically diseased. If both eyes have been originally the seat of the disease, panophthalmia may form on both sides.

The swellings in the eye-lids may remain the same for a long time ; but, frequently, the swelling spreads under the inner corner of the eye towards the nostrils. The lids, as well as this tumour, have a high temperature ; and are at first soft and oedematous. Later, indurations form in the centre, which become larger and larger, and at last lie directly under the skin. The outside of these indurations is rough or smooth, and the skin on it may be moved. In rare cases, an abscess forms instead of the induration.

Besides the indirect affection of the eyes from the nostrils, there is a more direct way which is also very common. In such a case the cella infra-orbitalis is generally affected from the beginning of the roupy, nasal catarrh, and the retained secretions become so large that the bone-walls are pressed out in all directions. Later, these, under the ever-increasing pressure, become absorbed in some places ; as, for example, between the inner corner of the eye and the nostril. Here a hot tumor with a hard centre forms. The swelling quickly extends to the eye-lids, after which serous putrid, croupous-diphtheritic Conjunctivitis sets in. These tumors are well known among poultrymen, for they frequently recommend the opening of the tumors and "extracting the roots of the disease." The masses taken from the tumors form again, with great rapidity and obstinacy. Often, after there had been for an indefinite period only a slight swelling on the lids, even without conjunctival catarrh, blindness ensued without any preceptible cause. Later, the iris and pupil became grey, and the cornea cloudy. When the disease of the eye appeared in this way, the general condition was always very much disturbed. In these cases, the post-mortem examination showed that the phlegmonous processes had spread from the eye-lids into the loose tissue of the peri-orbital cavity ; and grey, streaked pus, or thick, well-marked, yellowish-white, cheese-like lumps of matter, like those in the eye-lid, were found.

### Mouth and Pharynx.

Mouth and Pharynx. Primary or secondary catarrh of the nose, croupous or diphtheritic membranes appear on the mucous membranes of the mouth and pharynx, especially about the fissure of the palate, on the hard palate, on the side of the mouth, near the larynx, and under the tongue. They are usually small, but they often grow to large, extended patches. The thickness varies from ½-4m.m. The outside is uneven or smooth. The color is yellowish-white ; in the older membranes, a light brown. They either adhere firmly, or fall off easily. In the former case, they leave a dirty, greyish mucous membrane which bleeds slightly ; in the latter case, the underlying mucous membrane appears unchanged. A slight reddening of the region of the mucous membrane affected, may precede the appearance of the pseudo-membranes. Usually, however, this is not the case ; but the mucous membranes is pale, with a grey surface, which can be easily removed as a thin membrane. This grey superficial membrane gradually changes to a croupous or diphtheritic membrane.

In fowls 1, 4, 9, and 10, the first stages of a diphtheritic membrane were present, and the ducts of the sub-lingual glands were filled with a clear, tough, gelatinous secretion, which was turbid, and which finally became a solid yellow-white membrane. At first, these membranes were arranged in lines on both sides near the tongue. Later, they spread farther and became a single large membrane. In addition to this, in fowl 9, there developed a large tumour in the submucous tissues, which contained a firm, cheese-like lump directly adherent to the membrane. Frequently large swellings in the region of the sublingual glands occurred, which then hardened to firm, smooth, or uneven tumours, while the mucous membrane of the mouth remained apparently normal. These tumours enclosed the above-mentioned cheese-like masses.

The pseudo-membranes in the mouth may appear in a third way, which usually happens in more severe types of the disease. The Cella infra-orbitalis becomes distended on all sides by the secretion retained in it. For this reason, it presses the palate towards the mouth-cavity. The palate, therefore, may thus attain twice and three times its regular breadth (as in fowls 5 and 27). Where the pressure is strongest, the bone stratum becomes absorbed, and a typical pseudo-membrane forms. This latter may easily be removed ; and if left it communicates directly with the firm cheese mass in the infra-orbital cavity.

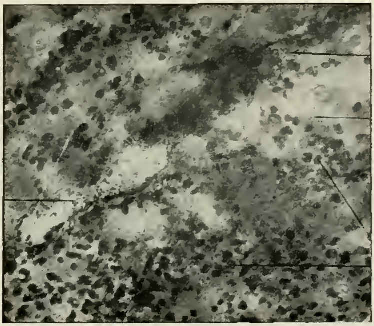


Fig. 4.—Section through a firmly attached false membrane from hen No. 17. *a* An altered epithelial nucleus not quite in focus, and consequently, not sharply outlined. *c*. Nuclei of the leucocytes. *d*. Granular detritus. *e*. A number of bacteria in the middle of an homogeneous fibrinous exudate.

In fowls 14 and 17, in addition to diphtheritic membranes on the mouth near the angle of the beak and at the nostrils, tumors were formed on the skin. These grew to the size of a pin head, or the pit of a cherry. The feathers on the tumours fell out, and the skin beneath was found to be covered with grey scales. The tumours were in direct connection with the pseudo-membranes on the mucous membranes, and formed a grey, dry, crumbly mass.

While in the cases under observation, the region around the larynx was very often the seat of croup-membranes, the disease never passed into the larynx or the trachea. Yet, according to the statements of many others, these organs are favorite places for the development of pseudo-membranes in the course of American Fowl Diphtheria.

Severe pneumonic dispnoea appeared in fowls 1, 6, 12, 18, and 19. The thoracic walls were used for inspiration and expiration. The beak and larynx were always kept open. The visible mucous membranes, the crest, and the wattles became cyanotic. The dispnoea grew worse and worse, and led to suffocation in 1 to 4 days.

In fowls that had been sick a long time, catarrh and inflammation of the bowels set in (hens 3, 4, 13, and 18). The fowls then stopped eating altogether. A severe, putrid diarrhoea followed; the feathers around the cloaca became smeared and matted with greyish-yellow, fluid excrement; and the fowls soon became as thin as skeletons, and usually died from loss of strength.

## General Symptoms

Corresponding to the polymorphic local appearances of roup, the general symptoms are also very different. As long as the disease exists only in the form of simple catarrh of the nose, slight affections of the mucous membranes of the mouth, and of the lungs, the general condition is quite normal. In all chronic, or more severe cases, especially after the appearance of swellings on the face and eye-lids, the general condition is disturbed. The sick fowls become weak, separate themselves from the other birds, and cower in a corner

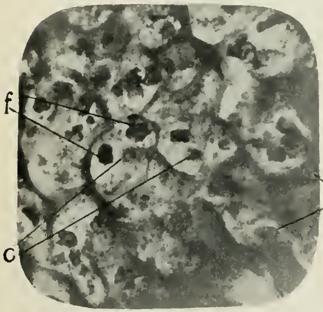



Fig. 5.—Section through the newly formed diphtheric membrane from hen No. 28. *a.* Swollen epithelial nuceli which stained but slightly. *b.* Remains of epithelial nuclei associated with Kitt's "Molluscum bodies" in the epithelial cells.

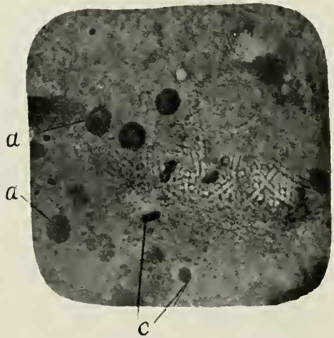



Fig. 6.—Cover-glass preparation from the upper epithelial layer under a false membrane of hen No. 18 stained with methyelene blue. *a.* Much swollen epithelial nuclei with or without nucleoli. *c.* Nuclei of leucocytes.

of the yard with head drawn close to the body. The eyes are kept shut, and the head is often drawn under the wings, so that the feathers are smeared with the secretions and fall out. The birds often wake up from this sleeping position, rise, open their eyes, shake themselves, scratch the swollen places with their feet, walk around a few steps, and take some food or water, and sink back again into their apathetic condition. Usually the disturbance of the general condition fluctuates, that is, the birds for a few days often appear in better condition, or normal, and then become worse again. Towards death, they lie down on the floor of the cage and usually do not get up again.

At first, the appetite is not impaired; later, it fails, but often continues for a long time. The taking of food may become quite impossible from purely mechanical reasons. For example, with fowl 5, the lower mandible was dislocated by the cheesy mass in the nostrils and infra-orbital cavity, and could not be closed. In many cases, there is a pronounced thirst. The fleshy condition of fowls attacked by roup usually becomes worse with the chronic continuance of the disease. The flesh of fowls which die after a short attack, is less affected. As for the body temperature of birds with diphtheria, it is the universal statement that the body temperatures are high in diseased birds. The English and American text-books on poultry all speak of fever as the constant accompaniment of roup. But, according to our observations, their statements on this point are incorrect ; and our conclusions are confirmed by the investigations of Friedberger-Froehner. The temperature of the head is very often above normal ; but in numerous cases in which we have taken the body temperature of roupy birds, there has been no increase ; or at least, no considerable increase. The highest temperature that we ever found was 42 degrees C. in a perfectly healthy hen. The minimum temperature of healthy, as well as diseased, fowls, was 40.2-40.8 degrees C., the average being 41.5-41.8 degrees C. In all simple catarrhs of the nose the prognosis is a favorable one. As soon as complications set in it becomes bad.

Fig. 7.—Fowl No. 47 inoculated with *B. pyocyaneus.*

The course of roup, with few exceptions, is chronic ; it lasts weeks, and even for years. Certainly the cause of its becoming chronic lies for the most part in the condition of the exudations or diseased secretions and their localization. Slighter affections of the nose very frequently disappear. If, however, the conchae or the infra-orbital cavities are attacked, or the nose passages become filled with solid masses of exudation, a natural recovery is either impossible or very slow. As has been described, these firm exudation masses become very large in a short time ; they act like foreign bodies, setting up irritation, and become larger and larger by the continued transudation ; and, by reason of the pressure of these bodies, various kinds of hypertrophies and atrophies ensue. They can be discharged only after having become softened and liquefied ; and such cases appear but seldom, while the cheesy matter in the nose, as well as under the skin, shows no inclination to become so. They, therefore, remain where they were formed, and lead to chronic catarrh. Often there is apparent recovery, so that for a few days or weeks, the clinical symptoms vanish. Then the catarrh again becomes manifest. These cases of apparent recovery are very important, as birds in this condition spread the disease if put among healthy ones. The pseudo-membranes in the mouth and pharynx may be of a very transitory nature. They appear first here, and then there, and but seldom disappear permanently, so long as any of the other

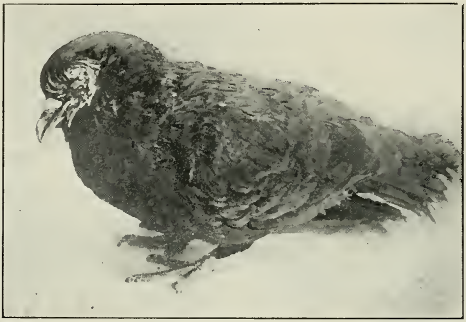


Fig. 8.—Pigeon (No. 6) 13 days after inoculation with culture of the Roup bacillus, (*B. cacosmus*) and two days before death.

symptoms of roup are present. In some cases (hen 28), the pseudo-membranes form again with great obstinacy in a certain spot. In these cases, poultrymen describe the trouble as cancer of the mouth. In a few exceptional instances, death occurs after a short sickness. Hen 9 died in this way after symptoms of roup had been recognizable for only two days. This bird showed a strong, hemorrhagic inflammation of the mucous membrane in the olfactory region, as well as swollen vessels in the meninges. Usually, however, death does not come until the disease has run for some time. The direct causes of death are anaemia, suffocation, inability to take nourishment, inflammation of the brain from the nose or eyes, invasion by decaying products of albuminoid substances, and intoxication with bacterial poisons.

## Pathological Anatomy.

In addition to the pathologic-anatomical changes already cited in the clinical account, the post-mortem examinations furnish other data. In diseased hen 9, mentioned above, the nasal passages were completely closed by dry, chessy masses, without any apparent clinical symptom. The bird had been sick two days and showed small bloody extravasations in the upper parts of the nasal mucosa. The mucous membrane itself was very much inflamed.

The eyes were quite normal. The cheesy mass must, in this case, have formed very quickly, and without being preceded by serous-purulent catarrh. This, however, was the only case in which there was hemorrhagic inflammation. The diseased mucous membranes were, in other cases, always swollen ; but dirty grey, or brownish in color. They were covered with a grey, putrid mass. Sections through the mucous membrane showed the epithelial cells with cloudy, or finely granular, protoplasm. The nuclei were, in most cases, normal ; some were swollen, homogenous, and difficult to stain, excepting one or two extra round central corpuscles, which stained deeply. Many leucocytes were present between the epithelial cells. They were usually rather long in shape,

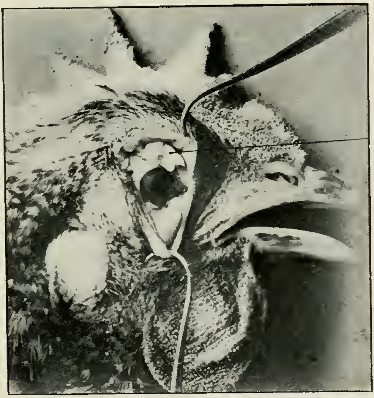



Fig. 9.—Head of fowl 36, 22 days after inoculation with a culture of the Roup bacillus. *a*. Firmly adherent thick diphtheritic membrane upon the conjunctiva of the upper eyelid.

and were found migrating towards the surface. The sub-mucous tissue showed a numerous increase of leucocytes, and dilated vessels. The leucocytes which migrated to the surface of the mucous membrane became free, and often joined the firm, cheese-like bodies which have been described. As these grew very quickly, they produced various deformities.

The mucous membrane may disappear entirely, or be changed to a brownish tissue of round cells, which are identical with the pyogenous membrane enclosing the cheesy matter in the sub-mucous tissues, etc. In one case (diseased hen 1), part of the mucous membrane of the nose was dry and necrotic. It consisted of a yellowish, dry, crumbly mass, which easily fell away from the cartilage. The latter was itself necrotic. Very often the medial wall of the infra-orbital cavity was absorbed, and then the solid mass of cheesy matter was in direct connection with that in the free nasal cavities. For this reason, the cheesy mass appeared to have grown fast, which, however, was not the case.

In fowl 28, a large part of the solid cheesy matter in the infra-orbital cavity became softened and semi-liquid. The surrounding membrane had changed into a red granulation tumour, which was full of vessels and projected into the cavity. It was lumpy, very soft, and contained in its depths an epithelial layer which grew toward the outside. The conchae of the nose may have been altogether absorbed under pressure of the solid cheesy mass.

The inflamed conjunctiva behaved like the mucous membrane of the nose, except that pseudo-membranes were more frequently formed on them. In the submucous tissue of the eye-lids, which had been serious'y infiltrated at

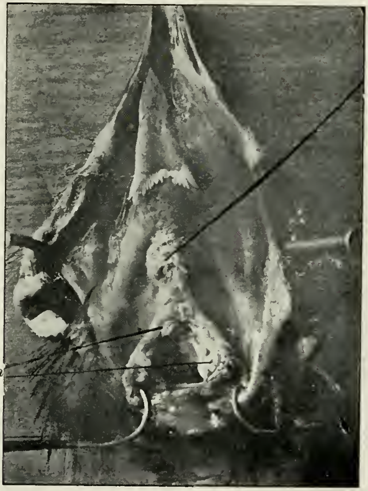



Fig. 10.—Fowl 46; throat and bottom of the mouth with false membranes (*m*), 14 days after inoculation with B. pyocyaneus.

the beginning, small, grey bodies of matter were found; these grew large, united and finally became compact, cheese-like yellow-white tumors. The surrounding tissue was sharply separated from these by a greyish-brown, smooth, pyogenous membrane, 1-3 m.m. thick. Usually the pseudo-membranes of the conjunctiva which at first were easily detached, were later firmly fastened to the cheesy massses in the depths of the lids. The firm, cheese-like masses in the lids showed no inclination to become soft, or to perforate the skin, like those formed in other places. On the inner and exterior sides of the lid of infected fowl 35, pseudo-membranes were formed, which had grown fast to one another. Similarly, the whole cornea of fowl 11 and inoculated pigeon 16 were changed to a diphtheritic membrane. If putrid panophthalmia appeared, the bulbus oculi shrank ; the corpus vitreum became grey with pus, and partially softened; and the retina was in shreds.

In birds that were suffering clinically from pneumonic dispnoea, and often in those that had not shown any symptoms of disease of the lungs, the post-mortem examination revealed extended pneumonic patches.

In the region of this inflammation, the branches of tracheae were stopped with firm, yellowish-white masses of exudation. Often in the centre of the pneumonic region, a mass of cheesy matter (from 1-2 cubic centimetres in size) was found connected with the masses in the branches of the trachea. These masses of cheesy matter were separated from the lung tissues by a brownish-

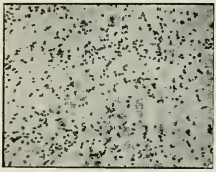

Fig. 11.—Head of hen 35, 8 days after inoculation with a culture of the Roup bacillus. *a*. Cheesy matter projecting from between the soiled and featherless eyelids. Nostrils are closed by a crust of dried secretion.

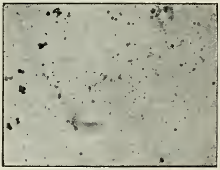
red granular membrane. The more peripheral parts of the diseased lungs were usually normal, or oedematous. The changes in the lungs were often accompanied by cheesy exudations into the pleural folds betweeen heart and lungs. These grew to 3 cm. in length and were often 1 cm. in thickness and breadth. They were always covered by pleura. The latter, however, changed to a brownish, pyogenous membrane, from 1-5 millimetres thick. It was smooth on the outside, but the side, turned towards the exudation, was somewhat uneven, and covered with gray pus. Twice in the pericardium (diseased fowls 6 and 18) a somewhat grey, serous-purulent exudation was present. The pericardium and epicardium were gray. Firm, cheese-like exudation masses were often met with in the folds of the mesentery, between the intestines, gizzard and stomach. In fowls 4 and 18, the mucous membranes of the intestines were haemorragically inflamed.

The heart blood was always well coagulated, the spleen small and normal, the liver normal or enlarged, with fatty degeneration.

### Croupous and Diphtheritic Membranes

Croupous and Diphtheritic Membranes. The pathologic anatomical conditions of the pseudo-membranes in mouth, eyes, etc., varied considerably. The small, grey, thin pellicles, which are often the first stage of the membranes, were found to be the outer epithelial-layers mingled with leucocytes. Sections of the epithelial-layers showed these to be more or less invaded by leucocytes, while the submucous tissue usually seemed intact. In all more severe cases, however, the loose, submucous tissue was completely filled up with leucocytes. The epithelial layer underwent changes, especially in the middle layer. The epithelial cells were dislodged from their normal position by fibrinous putrid exudation (Fig. 2). They lost their contour, and the protoplasm became





Figs. 12 and 13.—The Roup bacillus (*B. cocosmus*) magnified about 850. The bacillus is stained with gentian violet, the flagella by Van Ermegem's method.

cloudy or decayed to a granular detritus. The cell-nuclei swelled till they became two to six times their normal size, and the contents of the nuclei became homogenous and were difficult to stain, except one or two round, central or excentric nucleoli.

Often, too, the plasm of the nucleus became a fine granular detritus. These granules could then be deeply stained. The abnormal nuclei remained round and sharply outlined by thin nuclear membranes. They appeared like foreign bodies, and have usually been pronounced to be protozoa. Fig 3 shows these transformed nuclei, in which the edges of the separate cells have completely vanished and changed to a partly granular, partly turbid, decayed mass. In these cells there were a few nuclei of normal size ; (a) the greater number, however, were swollen in varying degrees, with one or two well stained nucleoli ; (b) the contents of the swollen nuclei, when freshly examined, were found to be homogeneous (see Fig. 6) ; but in Fig. 3, they appear granular, which is due to the treatment of the section while hardening was going on. In (c) we see leucocytes ; at (d), two bacteria. The swollen epithelial nuclei are also distinctly visible in the markedly changed middle epithelial layers of Fig. 2 (c).

The swelling might be caused by the simple coagulation of the protoplasm, following death ; or there was a mucous or colloidal degeneration. The latter was so much the more probable, as changed nuclei were found in the gelatinous mucous masses in the eye and in the glanular canals. A certain interchange, therefore, seemed to exist between the two. The transformed nuclei were fairly resistent, which might be due to the condition of the nuclear membranes, for, while the cells themselves decayed, the nuclei lasted for a long time. They were constantly found in all more severe cases of pseudo-membranes. Transformed nuclei might be seen in the slimy-putrid secretions of mucous membranes, in the cheese-like exudations in the nostrils, eyes, bronchial tubes, lungs, pleural and peritoneal folds ; or, in other words, wherever there were epithelial or endothelial cells. They were not found in the solid masses of matter in the lids and in other submucous or subcutaneous tissue.

In the above-mentioned jelly-like exudations, the products in the eyes of fowls 35, 36, etc., the epithelial nuclei were greatly swollen. They were homogeneous, clear, with or without nucleoli.

While the changes described in the middle epithelial layer were taking place, compact masses of pus were deposited over this layer and the pseudo-membranes were thus formed. All membranes which could be easily removed became separated from the region of the middle epithelial layer (Fig. 1). We then had typical croup membranes and a regeneration of the epithelium took place from the lower layers. In those cases in which the membranes were firmly attached, even the lowest epithelial layers were very much altered. They were swollen and loosened by fibrous purulent exudations. Under the lasting invasions of the leucocytes, the constituents of the epithelium were lost. The compact mass of epithelial pseudo-membrane advanced towards the lower layer of the epithelium, and finally reached the submucous tissue and thus became a typical diphtheritic membrane.

Submucous glands were often partly, or altogether filled with leucocytes. In typical diphtheritic membranes small quantities of fibrous exudation were found especially in the region of groups of bacteria. The croup-membranes, the cheese-like bodies in nostrils and eye-lids, in bronchii, pleura and peritoneum, as well as the firm masses in the different tumors of the head, were made up of leucocytes, granular detritus, of bacteria and eventually, of a remnant of epithelium and foreign bodies.

### Bodies Resembling Protozoa.

When the secretions and exudations of birds affected with roup contained remains of epithelium, the round, protozoa-like epithelial nuclei, referred to above, were present. Besides these, other very different bodies, which often more or less resembled the protozoa described as the cause of fowl diphtheria, or epithelioma contagiosum, were seen. No case of epithelioma contagiosum came under our observation. Table 1 shows some of the protozoa-like bodies found. These figures were drawn from fresh preparations which had been stained either with methylene blue, gentian violet, fuchsin, or Lugol's solution. The material was quite fresh, or had been stained without drying or heating. Many peculiarities could be distinguished with the methylene blue or Lugol's solution. The commonest forms of protozoa-like bodies were the swollen epithelial nuclei, which have been more minutely described above. They were always most numerous on the outside of the cheese-like matter in nostrils, eyes, and bronchial tubes, as well as on the underside of the pseudo-membrane, or in the material which was scraped from the mucous membrane. The other protozoa-like bodies were present in the greatest numbers in material from the same source. If we compare the drawings of the different bodies in (Figs. 14-25), we find very many forms which agree with the protozoa found by Rivolta, Silvestrini, Magganti, Piana, Pfeiffer, Babes, Puscariu, and Galli-Valerio.

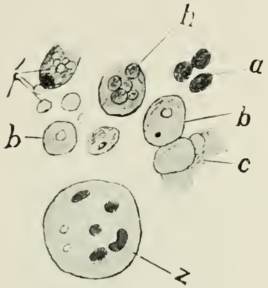



Fig. 14.—Protozoa-like bodies from the bronchial exudate of pigeon No. 1. *a* The nuclei of leucocytes. *b*. Swollen epithelial nuclei with or without nucleoli. *f*. Fat droplets. *h*. Yeast cell with spores. *z*. Probably a giant cell. Epithelial nuclei have a diameter of 8-10 μ, the other bodies are drawn on the same scale.


Fig. 15.—Bodies from the slimy purulent nasal secretion of pigeon No. 12. Same lettering as figure 14.

Round, amoeba and crescent-shaped forms, etc., were often present and the contents of these bodies were homogeneous, granular, or partly homogeneous and partly granular. They stained either badly, or not at all. Very often, one or more nucleoli were present which appeared in unstained preparations as clear or reddish spots. In stained preparations, the one small nucleolus was often stained, while the other in the same cell had not taken the stain at all. Besides these central bodies, the protozoa-like forms often held enclosed larger, clear vacuoles, which could be stained black with osmic acid, and were, therefore, fat globules. Other similar globules as they appeared in pigeon 4, and hen 7 gave no fat reaction and might have been true protozoa, but were more probably yeast-cells. Such accidental existence of foreign bodies in the exudations is not a rare thing, as is shown by Figs. 18, 19, 22 and 23. Very many of the protozoa-like bodies were either enclosed in the remains of cells, or showed debris of cells that had been present.

Twice, motile protozoa were present. In the bronchial tubes of infected hen No. 41, there were some oval forms which moved by means of a wreath of short cilia around the head end. (Infusorium diplodinum (See Fig. 22, i).

On the surface of the firm exudations in the mouth of pigeon 6, round, granular forms, each with three long cilia, were present. There is nothing remarkable in this, for motile protozoa were frequently found in the mouth cavity and intestines of perfectly healthy fowl.

Kitt describes and gives drawings of protozoa, or "Molluscum-Koeper," as he describes them. They are irregular bodies which stain intensively, and were found in the cells of an epithelioma.

We observed the same bodies in the epithelial cells under the pseudo-membrane in the mouth of fowl 28, and they are shown in Fig. 5. Unstained, they were homogeneous, clear and greenish in color. They were stained dark blue with haemotoxylin. In those parts of the epithelium in which these bodies were absent, the cell nuclei were homogeneous, or finely granular, and very much swollen. The clinical form of this case of the disease was striking because the membrane always formed again with extraordinary obstinacy, and in some cases grew right into the bone tissue of the left lower jaw. Similar bodies were present in the exudation of bird 26, and inoculated fowl 29.


Fig. 16.—From the eyelid of fowl No. 29 structures resembling Kitt's "Molluscum bodies."

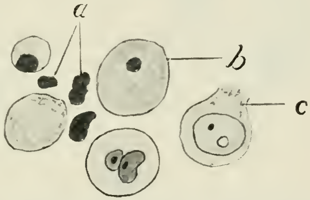



Fig. 17.—From the secretion and exudation from the eyelids of hens u 35, 36 and 39. Swollen epithelial nuclei are 16 u in diameter.

As appears from the drawings, the most varied protozoa-like bodies were present in the secretions and exudations, of naturally diseased fowls and of those inoculated with bacterial cultures.

In conclusion, we may state that most of the above described bodies were probably different products of degeneration of the epithelium and endothelium. Some must be regarded as foreign bodies and protozoa accidentally present in the exudations.

Kitt's molluscum bodies, in the epithelium of fowl 28, resemble the cell enclosures frequently found in Carcinoma, which are claimed by some as being the causal organism.

### Bacteria.

In all the pathological exudations and secretions, bacteria were present. Cultures in gelatine and agar plates and aerobic and anaerobic cultures in bouillon were usually made. In some cases, the material was only examined microscopically. In six cases of diseased fowls (29, 30, 33, 34, 35 and 36), B. pyocyaneus in pure cultures grew from spleen, liver, kidneys and blood. In all other cases, either some colonies of B. coli grew from cultures made from these organs, or the cultures remained sterile.

Frm the exudations and secretions, many different micro-organisms developed, and occasionally, yeasts and fungi were present. The colon bacillus was sometimes isolated, and a large number of other bacteria-cocci, bacilli and a spirillum. The spirillum which had three or four turns could not be grown in any culture medium. Some five or six of the other micro-organisms were grown in pure-cultures, and their pathogenic properties were investigated by inoculations into guinea pigs, mice, and chickens. No results followed these inoculations ; and, consequently, we must regard these forms as purely adventive.

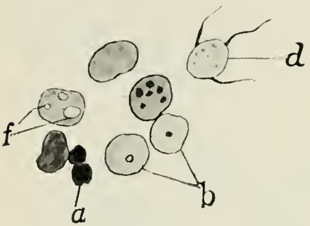



Fig. 18.—From the cheese-like exudate from the *cella infraorbitalis* of pigeon 6. *d*. Is one of the Flagellata with three motile flagella.

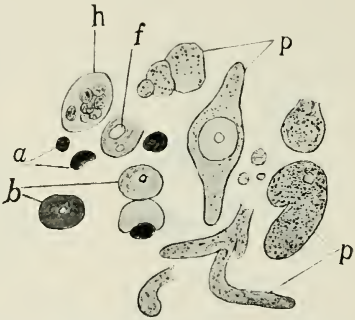



Fig. 19.—From the underside of a diphtheri-membrane from hen No. 7. *p*. Probably some form of vegetable life.

We succeeded, however, in isolating two virulent forms of bacteria. The one was a typical Bacillus pyocyaneus. This bacillus was present in the cheese-like masses in the lungs of hen 9, in company with a few B. coli ; in the firm exudations of the Cella infra-orbitalis of hen 32 ; in the cheesy masses of hens 29, 30, 31, 33, 34, 35, 36. In the six cases last mentioned, the bacillus was also isolated from the blood, liver, kidneys and spleen. Five of these birds were killed and had been dissected at once.

This Bacillus pyocyaneus was, as the inoculation experiments show, capable of producing typical croupous and diphtheritic membranes in mouth and eyes ; it was the cause of severe tumors in the submucous, or subcutaneous tissue, the contents of which were firm, cheesy and yellowish-white. It produced purulent conjunctivitis ; blindness ; purulent panophthalmia; inflammation of the lungs ; and hard cheese-like exudations in the bronchial tubes. In a word, it produced symptoms identical with those of roup.

The second virulent form of bacteria isolated seems to be a new organism. We have named it B. cacosmus and shall also refer to it as the roup bacillus. It was in great numbers in the croupous membranes under the tongue of hens 1 and 9 ; in the cheesy material of the tumor on the head of hen 5, as well as in the purulent conjunctival secretion ; in the nasal secretion of hen 4 ; in the purulent masses which closed the lacrymal duct of hen 21 ; and was also found in a number of other birds affected with roup.

Further, this bacillus was repeatedly isolated from the secretions of the hens and pigeons which had been inoculated with it. At first, it was usually present in the tumors of the submucous or subcutaneous tissue in pure culture. Later, it was found mixed with other bacterial forms in the tissues and also in the exudation products. In chronic cases of the disease, the roup bacillus could not be culturally detected, but it could often be identified microscopically in the cheese-like masses of diseased or inoculated fowls. We have never isolated this bacillus from the blood or other internal organs.

### Morphology of B. Cacosmus.

The roup bacillus is a small rod .25 to 5m.m.m. thick, .25 to 5m.m.m. long, with rounded ends. It often occurs in pairs and occasionally in short chains of 4 or 5 cells. The smallest forms are coccus-like, the longer are rods. With the ordinary aniline stains, they stain very well. In old bacilli, there are often only zones or parts of the cell that take the stain (involution forms). The bacteria are not stained by Gram's method. In young agar or bouillon cultures, the roup bacilli are very motile. They possess 4 or 5 peritrichous cilia which are three or four times as long as the bacilli. Capsules and spores are not formed.

### Cultures.

Gelatine Plate Cultures. Colonies appear in 24-28 hours as small, round, iridiscent points, which grow slowly. They are flat, round, or somewhat irregular in shape. They never become prominent ; but, as their growth continues,

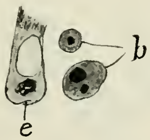



Fig. 20.—From the nasal secretion of hen 11 and 26. Ciliated cell showing slimy degeneration.

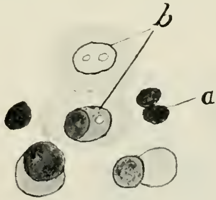



Fig. 21.—Bodies from a tumor from hen No. 17.

they sink deeper into the gelatine. The surface is smooth and shining. They are light grey in color. Through the microscope, young colonies are seen to be slightly granular. The centre is dark, yellowish or brown, the border zone clearer, and usually provided with darker, radiate markings ; in older colonies, these disappear, and the gelatine becomes liquefied to the bottom of the plate. The growth at the edge of the colony lasts for about 8 days, and then ceases. In this time, they usually reach the size of from 3-5 mm., while after two days they were from 1-2 mm. in size. The submerged colonies appear as round, slightly granular, clear points, which quickly penetrate to the surface of the gelatine.

Gelatine Streak Cultures. Along the needle track, a thin, grey, shining growth appears, under which the gelatine soon becomes furrowed. The groove sinks deeper into the gelatine, and the liquefied gelatine and the bacteria flow as a turbid mass to the bottom of the tube.

Gelatine Stick Cultures. After 24-28 hours, a homogeneous, fine, grey band forms along the line of puncture. At the same time, on the surface of the gelatine, a smooth, fine covering grows, and, after two or three days, the gelatine becomes liquefied slowly around the puncture, spreads gradually over the whole surface of the gelatine, and then the liquefaction becomes stratiform. The liquefied gelatine is turbid, but never ropy. On the surface of the solid gelatine, a copious grey sediment settles. After two or three weeks, when about 2-3 of the gelatine has become liquefied, growth ceases. The liquid mass gives a very strong alkaline reaction, and has a very disagreeable putrid sm ll.

Agar Plate Cultures. At 37 degrees C., in 24 hours the surface colonies appear as smooth, gleaming points, which grow quickly into round or irregular shaped masses. The centre becomes somewhat thicker and greyer. After two days, they are three to five mm. in diameter. The whole colony has an iridiscent lustre. Deep colonies appear as grey points. Seen through the microscope, they are round, or somewhat irregular, clear, and darker at the margin.

Agar Streak Cultures. The culture spreads over the whole surface, and forms a smooth, faintly gleaming, thin, grey cover, which appears blue when the light falls on it. The condensation water becomes turbid and grey. On

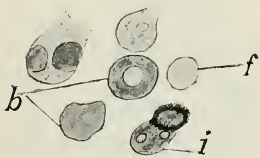



Fig. 22.—From the bronchial exudate No 16. *i.* A motile infusorium with ciliated crown.

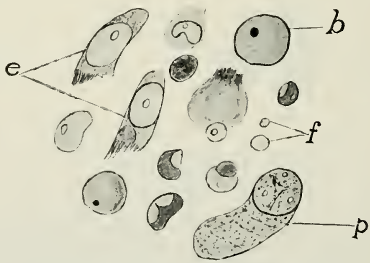



Fig. 23.—Bodies from the slimy pus from the *Regio olfactoria*, or hen No. 23. *e.* Ciliated cells with swollen nuclei. *p.* A foreign body, perhaps of vegetable origin.

agar, with 5 per cent. glycerine, the growth is the same, only much slower.

Bouillon Cultures. In 24 hours, the bouillon is uniformly turbid. The reaction is unchanged, and a grey sediment forms which diffuses uniformly when the test-tube is shaken. After 4 or 5 days, a thin, grey pellicle appears on the surface, which is easily broken and then sinks in shreds to the bottom of the tube. The culture has a very disagreeable, sweetish odor. Old cultures are always very alkaline. Very old cultures become completely sedimented, and brown in color. Growth occurs in slightly alkaline or acid bouillon, and small lumps appear in the sediment.

Milk Cultures. In four days, the milk coagulates into a soft curd with a thin layer of turbid, yellowish-grey serum on the surface. The reaction is slightly alkaline, and the curd digests slowly, as it takes about four weeks for the curd to completely dissolve. The liquid is turbid, yellowish-grey in color somewhat thick, and with an alkaline reaction. There is usually a thick, greyish-white sediment. The culture has a disagreeable odor.

On Potatoes, the roup bacillus develops fairly well, as a thin, grey, smooth and shiny layer.

In Dunham's solution, a uniform turbidity appears. At the bottom, a grey, flocky sediment forms. After three or four weeks the culture is dark brown, very alkaline, and has a putrid odor.

1 per cent. solution of Peptone with 4 per cent. Dextrose. In this medium, a copious, diffuse turbidity forms, as well as a granular sediment. 14 per cent. of gas collects in 48 hours. The reaction is slightly acid, and remains so.

Temperature relations. The roup bacillus grows best at a temperature of 37-40 degrees C., and it also grows well at room temperatures, 20-22 degrees C.

The thermal death-point (Sternberg's method) is 65 degrees C. for 10 minutes.

Oxygen requirements. It grows best aerobically. Anaerobic cultures are poor, and grow very slowly.

Relation to sunlight and dessication. An exposure of 2 hours to direct sunlight (Lat. 42) kills the bacillus exposed in agar dish cultures. It succumbs to dessication in 6 days.

Action of disinfectants. The disinfecting power of the following chemicals was :

| | |
|---|---|
| Corrosive sublimate, 1 per cent.... ..... ........ | 10-15 seconds. |
| Lysol, 2 per cent. ... ... ... ... ..... ... ... ... | 1½-2 minutes. |
| Carbolic acid, 5 per cent. ... ... ... ... ... ... ... | 12-15 seconds. |
| Creolin and glycerine, equal part, 5 c.c. in 100 c.c. water (Friedberger-Froehner).......... ..... .... | 1-2 minutes. |
| Lime water (Sat. solution) ... ... ... ... ... ... ..... | 10-15 minutes. |

### Virulence.

The virulence of the roup bacillus was at first weak, but was much increased by passing once or twice through pigeons. Like B. pyocyoneus, the roup bacillus produced suppuration, but the effect was strictly local.

Pathogenesis. Rabbits die after an intraperitoneal inoculation of 1 c.c.

of a young bouillon culture in from 18 to 24 hours. Dissection shows a widespread, purulent peritonitis, with slight bloody extravasations of the peritoneum. Subcutaneous inoculations of small quantities of bouillon cultures lead to hot tumors, which spread quickly and in which firm, hard centres form. The whole tumor gradually assumes the same hard, uneven condition. The skin becomes dry, cracks, splits and forms a brown, thick crust which, after some time, falls off. Under the crust, there is an extensive, uneven yellowish-white, cheese-like mass, 2 mm. to 2 cm. thick, firmly adherent to the underlying tissue. Gradually this mass falls off, and regeneration of the tissue from the edges of the skin follows. The hard, cheese-like masses look exactly like the croup and diphtheritic membranes of fowls and pigeons. They consist

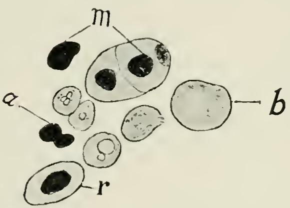



Fig. 24.—From the nasal secretion of hen No. 6. *m.* Kitt's "Molluscum bodies." *r.* A red blood cell.

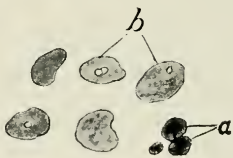



Fig. 25.—Bodies from the under side of a false membrane from pigeon No. 11.

of bacteria and leucocytes, as well as of some detritus. The general conditions of the rabbits is poor, so long as there is a hot tumor. Later, their condition improves, though the animals remain very thin in spite of being well fed. In a few cases, sympathetic inflammation of the eyes, purulent conjunctivitis on one or both sides, purulent panophthalmia, perforation of the cornea, etc., occur during the course of the healing of the local lesions. If there are no complications, the local lesions heal in from 3-5 weeks ; if the described complications set in, death comes after the disease has run its course for 1-3 months.

Old cultures filtered through Chamberland filters, produced, when inoculated intraperitonealy, neither death nor sickness.

Guinea Pigs. The effect of the roup bacillus was the same on these animals as on the rabbits.

Mice die in 12 to 18 hours from inoculation with 1-8 to 1-4 c.c. of a bouillon culture of the bacillus. Dissection shows excessive swelling of the spleen. Intraperitoneal inoculation gives rise to hemorrhagic purulent peritonitis. The bacilli are present in great numbers in the exudations and spleen ; whilst they are but seldom found in the blood.

The effect of the roup bacillus on hens and pigeons, is shown in the following table of inoculation experiments.

### Table of the Natural Cases of the Disease.

| Number. | Slimy, putrid conjunctivitis with or without a soft swelling of the lids. | Pseudo membranes on the conjunctiva or cornea. | Phlegmonous swelling of the lids with hard putrid centre. | Diseases of the inner eye. | Submucous or subcutaneous tumors with solid putrid centre. | Slimy putrid catarrh of the nose and the secondary cavities of the nose. | Pseudo membranes in mouth and pharynx. | Pneumonia with or without exudations in the bronchial tubes, etc. | Affection of the pleura and peritoneum. | Catarrh and inflammation of the bowels. | Chronic x, Acute — course of the disease. | Condition: Thin x, Good — | Recovered o, Died x, Killed — |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | x | .... | x | .... | x | x | x | x | x | .... | x | x | x |
| 2 | x | x | .... | .... | .... | x | .... | .... | .... | .... | x | x | o |
| 3 | .... | .... | .... | .... | .... | x | .... | .... | .... | x | x | x | x |
| 4 | x | .... | x | x | .... | x | .... | .... | x | x | x | x | x |
| 5 | x | .... | x | .... | x | x | x | .... | .... | .... | x | x | x |
| 6 | x | .... | x | .... | .... | x | x | x | x | .... | x | x | x |
| 7 | .... | .... | .... | .... | .... | x | x | .... | .... | .... | x | — | — |
| 8 | .... | .... | .... | .... | .... | x | x | .... | .... | .... | x | — | o |
| 9 | .... | .... | .... | .... | .... | x | x | .... | x | .... | — | — | x |
| 10 | .... | .... | .... | .... | x | x | x | .... | .... | .... | x | — | x |
| 11 | x | x | x | x | .... | x | x | .... | .... | .... | x | — | x |
| 12 | x | x | .. | .... | .... | x | x | x | x | .... | x | x | x |
| 13 | x | x | .... | .... | .... | .... | x | x | x | x | x | x | x |
| 14 | .... | .... | .... | .... | x | x | x | .... | .... | .... | x | — | — |
| 15 | x | .... | .... | .... | .... | x | .... | .... | .... | .... | x | — | — |
| 16 | x | x | x | .... | x | x | x | .... | .... | .... | x | x | — |
| 17 | x | x | x | .. | x | x | x | .... | .... | .... | x | — | x |
| 18 | .... | .... | .... | .... | .... | .... | x | x | x | x | x | — | x |
| 19 | .... | .... | .... | .... | .... | .... | x | x | x | .... | x | x | x |
| 20 | .... | .... | .... | .... | .... | x | .... | .... | .... | .... | x | x | o |
| 21 | x | .... | .... | .... | .... | x | x | .... | .... | .... | x | — | — |
| 22 | .... | .... | .... | .... | .... | x | .... | .... | .... | .... | x | x | x |
| 23 | x | .... | x | .... | .... | x | .... | .... | .... | .... | x | — | — |
| 24 | x | x | x | x | x | x | .... | .... | .... | .... | x | x | — |
| 25 | x | .... | x | .... | .... | x | .... | .... | .... | .... | x | x | x |
| 26 | x | .... | x | .... | .... | x | x | .... | .... | .... | x | — | — |
| 27 | x | .... | x | .... | .... | .... | x | .... | .... | .... | x | x | — |
| 28 | .... | .... | .... | .... | .... | .... | x | x | .... | .... | x | — | — |
| 29 | .... | .... | .... | .... | .... | x | x | .... | .... | .... | x | — | — |
| 30 | x | .... | x | .... | .... | .... | x | .... | .... | .... | x | x | — |
| 31 | .... | .... | .... | .... | .... | .... | x | .... | .... | .... | x | — | — |
| 32 | x | .... | x | .... | x | x | x | x | x | .... | x | x | x |
| 33 | x | .... | x | x | .... | x | .... | .... | .... | .... | x | x | — |
| 34 | .... | .... | .... | .... | .... | x | x | .... | .... | .... | x | x | — |
| 35 | x | .... | x | x | .... | x | x | x | .... | .... | x | x | x |
| 36 | .... | .... | .... | .... | .... | x | x | .... | .... | .... | x | — | — |

### Experiments on Infecting Chickens and Pigeons.

Fowl Diphtheria or Roup, prevalent in America, appears and passes for an infectious disease, because we find that from twenty to ninety per cent. of all chickens in a flock may become diseased. It is, therefore, of great importance to know how infection takes place, and how the disease is transferred from bird to bird. In order to orient our observations with what has already been noted by others, it will be necessary to briefly summarize a portion of the literature which has appeared.

Zurn says that diphtheria is a highly infectious disease. He claims that secretion and exudation products of diseased birds are probable carriers of the poison, but he did not support this statement with experiments.

According to the statements of Siedamgrotsky, Friedberger and Perroncito, it is impossible, or very difficult, to infect healthy birds with the pathological products of roupy ones. Cornevin and Nicati, on the other hand, inoculated the pathological secretions of diseased birds into healthy chickens and rabbits, and produced diphtheria in these animals. According to Trinchard, it is easy to infect healthy birds, the time elapsing from the date of infection to the first symptoms of the disease being 7-20 days.

Babes and Puscariu were not able to produce the disease with diphtheritic membranes, containing bacteria and numerous trichomonas.

Massanti transferred the disease with fresh pseudo-membranes containing many flagellata. When he killed these protozoa with salt, he never succeeded in producing the disease. Loir and Ducloux infected healthy birds with the blood and any of the parts of organs from diseased ones. Kitt states that a transfer of croupous-diphtheritic membrane to healthy birds very frequently produces no infection. Friedberger and Froehner declare that diphtheria caused by protozoa can more easily be transferred to healthy fowls than diphtheria produced by bacteria.

Moore tried to infect healthy chickens with pathological secretions and exudations, and kept healthy fowls in with diseased ones ; but in no case was he able to produce the disease.

In the following experiments, the diseased birds were obtained from the poultry department of the Ontario Agricultural College. Most of the healthy ones were purchased from different farms where no roup was present, but a few were secured from the Poultry Department where they had been exposed to infection, but had never become affected.

### Experiments to Ascertain if Healthy Birds Become Affected When Kept with Diseased Ones.

Fowl No. 1. Small hen about 6 months old, in fair condition. To irritate the conjunctiva, a few drops of 2 per cent. acetic acid were dropped under the left eye-lid. Then the hen was placed in the cage with diseased chickens No. 1-5. 3 Dec. 01.

Dec. 9.—General conditions unchanged. From the left nostril a little serous fluid escapes, when one presses on the dorsal wall of the nose, more of this secretion exudes from the nostril.

Dec. 13.—The left nostril is closed entirely with dirty looking crusts of dried up secretion, mixed with food particles. Under this crust is a small quantity of a grey, sticky and putrid-stinking liquid.

Dec. 18.—Very copious stinking secretion runs from the left nostril. General condition disturbed. The bird generally stands at the back corner of the cage, in a crouching position, the head drawn close to the body and very often tucked under the wing. Eyes often kept shut, and the beak generally a little open.

Dec. 19.—Discharge from both nostrils. Nasal secretion is slimy and putrid.

Jan. 3, 1902.—Hen has lost very much flesh. All visible mucous membranes are pale. General condition occasionally normal, but generally greatly depressed. Appetite always fair. On the mucous membrane in the mouth is some sticky slime, and on both sides near the tongue there are two small greyish-white pseudo-membranes about 1 mm. thick. They can be easily removed. The mucous membrane under them is uneven, red and begins to bleed at various spots.

Jan. 8.—Pseudo-membranes have disappeared from the mouth. The left nostril is entirely closed by a dry, yellowish-white, cheesy mass, which can only be removed with difficulty, when the surface underneath bleeds. This diseased part was treated with a 2½ per cent. solution of Creolin.

Jan. 9.—At the place treated with Creolin yesterday, a new pseudo-membrane has formed. Treatment again renewed.

Jan. 11.—The left nostril again blocked up by the cheesy yellowish mass. In many places in the mouth, thin, grey pseudo-membranes and at two places on the left side of the mouth yellowish-white patches of croup-membranes have formed.

Jan. 14.—Both nostrils are free from any secretions, but the disagreeable smell continues. At several places in the mouth, small pseudo-membranes may be seen. General condition, fairly good.

From 15th of Jan. to 3rd of Feb.—Chronic catarrh of both nostrils, sometimes with serous, and at other times with much pus. From time to time, the discharge from the nostrils may stop for one or a few days. There is always a very bad smell present. Very often pseudo-membranes appear in the mouth, especially on both sides near the tongue, around the entrance into the larynx, or on the palate, etc., for one or a few days. They never grow larger than 1-4 cm. The general condition was always disturbed, sometimes more, sometimes less, with loss of flesh and anaemia.

Feb. 3.—Killed with chloroform.

Post-Mortem : Thin carcass.

Conjunctiva and mucous membrane of the mouth very pale, without pseudo-membranes. Nostrils are filled with dirty grey dried secretion. The mucous membrane in the regio olfactoria is very soft, red and swollen. It shows at several places, small, bloody extravasations. It is covered with a grey, slimy mass mingled with pus and bloody streaks. The lower parts of the nasal canals are blocked up with a mass, consisting of putrid slime, and solid granules of solid white pus. The whole mucous membrane and submucous tissues have disappeared. The cartilage of the left oral concha is at several places black, dry and necrotic, or grey with very bad smell. In the dorsal wall of the pharynx and the mucous membrane of the higher third of the oesophagus are very many lymphoid follicles, swollen and filled with a yellow cheesy matter. They extend often as deep as the muscles and consist of pus corpuscles and four different kinds of germs (short thick rods, single or generally two together ; long chains of another germ ; streptococci and staphlococci). The organs are normal ; spleen and liver small. Cultures from these two organs remain sterile. The putrid slime from the nostrils consists microscopically of slimy masses, desquamated epithelial cells, pus, erythrocytes and very many spirilla. A large coccus, several B. coli and aerogenes bacilli, and the roup bacillus in a few specimens, were isolated.

Fowl No. 2. Healthy cock, about one year old. 13th Dec. '01. Was kept in the same cage with fowl No. 1, and the diseased chickens 1-5.

Dec. 21.—General condition normal. At the right nostril, a small quantity of a clear serous fluid is visible.

Dec. 26.—The right nostril is entirely closed with thick grey, crusty secretion. On taking this away, large quantities of a grey, putrid, stinking slime exude from the nostril.

From Dec. 27 to January 10 there occurred chronic nasal catarrh ; sometimes discharging and at other times stopping. Offensive smell from nose and mouth. General condition not much altered ; appetite good. No pathological changes were observed on the mucous membranes in the eyes and mouth.

Jan. 29.—For eight days, the bird showed neither nasal catarrh nor any other abnormal appearance. Killed by decapitation.

Post-Mortem : Fairly well nourished carcass. In the nasal parts of the right ductus lacrimalis are some small, brown spots, encased in the mucosa.

Fowl No. 5. Large, strong, well-developed hen, about 1 year old. It was kept in a cage with infested fowl 4 for ten days.

Jan. 10.—Both nostrils are partly closed by a clear, serous slimy, fetid-smelling liquid. Mucous membranes very pale. General condition and appetite, normal.

Jan. 14.—At the entrance to the larynx, and on the dorsal wall of the larynx itself, a pseudo-membrane is located. It has an uneven surface, is yellowish-white in color, 1 to 2 mm. thick, and can be removed with little difficulty. The undersurface after removal begins to bleed at several spots.

Jan. 15.—At the place where the pseudo-membrane was removed, the mucous membrane is apparently normal. Discharge from the nostril almost entirely stopped.

From the 16th of January to the 4th of May chronic nasal catarrh of both nostrils, with fluctuating severity, occurred. Often the mucous membrane in the mouth had for one or several days small pseudo-membranes. General condition was abnormal during the later stages of the disease, with sleepiness, diminished appetite, and all visible mucous membrane pale. Chronic anaemia set in, as a secondary disease, following the roup.

Fowls Nos. 10 and 11 were healthy hens, about one year old. They were kept with the diseased chickens the second half of the month of December 1901, and the whole month of January, 1902. General condition remained unchanged. Eyes and nostrils remained normal. Several times on the mucous membranes in the mouth, small croupous membranes appeared for one or two days ; then they disappeared again. The mucous membrane was pale, and was sometimes covered with a sticky slime.

Feb. 6th and 7th.—Left nostril of hen No. 10 shows a small quantity of serous, odorless fluid, which had disappeared the next day. These two hens remained normal and healthy

Fowls No. 6, a., b., c., d., and e., were kept with the diseased chickens during the month of December, 1901, and January, 1902, without becoming infected. Later these chickens were used for experimenting with the roup bacillus, which had been made virulent by passage through pigeons. All reacted with typical symptoms of chicken diphtheria.

### Experiments to Show if Healthy Birds Could be Infected wtih Secretion or Exudations of Diseased Ones.

Fowl No. 4. Young, healthy hen. 17th Dec., 1901. Some of the solid, cheesy peritoneal exudation from diseased fowl No. 4, was rubbed on the sound or slightly scratched membranes (mucous) of both eyes, the mouth, and in the higher parts of the nostrils.

Jan. 18.—General condition normal. At the small scratch wound in the mouth the membrane is slightly swollen and red. A little clear, serous fluid exudes from the right nostril.

Jan. 19.—Mouth normal. Both nostrils are moist, with a little serous liquid having no smell.

Jan. 21.—The secretion from the nostril is grey, slimy and has a putrid smell. On the mucous membrane of the right side of the mouth, an irregular yellowish-white spot is located. It is about 1 m.m. thick and 1-2 cm. in size. This patch was taken off, and the membrane under it bled at a few spots.

Jan. 14.—Chronic, putrid nasal catarrh. General condition unchanged. Mucous membrane in the mouth always very pale, sometimes with small pseudo-membranes.

Jan. 21.—In the middle of the palate, a pseudo-membrane is located, about ¼cm.2 in size, and 1 to 1½ mm. thick. It was removed and rubbed on the left conjunctiva.

Jan. 22.—The membrane has reformed in the mouth. Eyes are normal.

Jan 23.—Some new membranes have formed at different places in the mouth.

From the 27th of Jan. till the middle of March, the chronic nasal catarrh disappeared, after having ceased several times for only one or a few days. The local infection in the mouth disappeared at the same time. General condition was good.

Fowl No. 5a. Healthy hen, half year old. On the 17th of December, some of the putrid nasal secretion from diseased chicken No. 4 was rubbed in and upon the mucous of the eye and the regio olfactoria.

This hen never became sick or diseased.

Fowl No. 7. A hen like No. 5a was inoculated on Jan. 3rd, 1902, with nasal secretion and pseudo-membranes from fowl 5. Inoculation on and under the mucous membrane of the mouth, and on the mucosa of the regio olfact. No visible reaction followed.

Fowl No. 9. This fowl suffered from chronic diarrhoea. It was kept in the stable for four months and then inoculated in eye-lids, mouth, and nostrils with croupous material from the eye-lid of diseased chicken No. 11.

Fowl No. 8. Healthy cock, three years old. Had been kept in the stable continually for three months.

Jan. 4.—On the scratched mucous membrane in the mouth near the tongue, a croupous membrane from fowl 3 was rubbed in.

Jan. 5.—The mucous membrane at the place of infection was red, and covered with much saliva. General condition, normal.

Jan. 6.—At the place of infection, the mucous membrane is uneven grey; at several places, yellowish-white points appear.

Jan. 7.—Near the tongue, a croupous membrane has formed, yellowish-white in color, 1 mm. thick and about 1 cm. in area. The surrounding mucosa is reddened. After having taken off the membrane, the mucosa begins to bleed. At several other places in the mouth, very thing, greyish pseudo-membranes formed.

Jan. 8.—The pseudo-membrane near the tongue, which had been removed yesterday, has reformed, and is larger than before.

Jan. 15.—At the primary seat of infection, the croupous membranes have disappeared, but a small croupous patch is located on the left side of the mouth, and there are four others upon the mucous membrane of the palate, near the entrance to the nasal cavity.

From the 16th Jan. till the 25th Feb.—Often pseudo-membranes appeared on the mucous membranes in the mouth, and disappeared again in a few days. The general condition at this stage was poor. All visible mucous membranes were pale.

This fowl was killed and the post-mortem examination showed the existence of anaemia. No growths in cultures from the spleen.

Fowl No. 21. Young, healthy hen.

Jan. 3.—Was inoculated with slimy, putrid, nasal secretion from fowl No. 1, containing very many spirilla. 1½ c.c. was injected into the mucosa and submucosa of the mouth and nose, ½ c.c. into the right eye-lid and ½ c.c. into the right pleural cavity.

Jan. 4.—General condition unchanged. Eye-lid slightly swollen and conjunctiva moist. On the palate, one pseudo-membranous patch has formed, ¼ cm. in size, yellowish-white and cheesy. Mucous membrane of the mouth is pale.

Jan. 7, and later.—General and local condition normal.

Fowl No. 24a.—This bird was inoculated the 23rd of January, 1902, with material taken from the cheesy, degenerate lymph follicles in the oesophagus of fowl No. 1.

Fowl No. 25.—This chicken was inoculated with a solid mass of yellowish pus taken from the eye-lid of diseased fowl No. 21.

In both cases, the eye-lids became swollen for a few days. The mouth remained unchanged, and the general condition was never disturbed.

Besides these experiments, we tried to infect six other chickens (6-12 months old) with pathological secretions and exudation products. Several times the eye-lids became swollen for a few days, but no typical roup disease could be produced.

These results show that out of 10 healthy chickens, kept with diseased ones, five became infected. In four cases, nasal catarrh appeared in from 6 days to 1½ months. In the same birds, pseudo-membranes sometimes appeared in the mouth for a few days. In fowl No. 10 only, they appeared without any changes in the nostrils. Five fowl did not take the disease at all, although they were exposed to the same infection.

Of the 14 chickens and 1 pigeon (see later) which we attempted to infect with secretions and exudations from diseased fowls, only two fowls (Nos. 4 and 8) became diseased with roup. These experiments show that chicken diphtheria, or roup, may be transferred.

### Experiments to Infect Healthy Fowls with Bacillus Cacosmus (the Roup Bacillus.)

Fowl No. 3. Small hen, weak constitution, about one year old.

Dec. 17.—The conjunctiva and the higher parts of the nasal mucosa were irritated with dilute lactic acid, after which a portion of a young agar culture of the roup germ (isolated from diseased hen 4) was rubbed in.

Dec. 18.—General condition unchanged. At the right nostril, some fluid can be seen.

Dec. 21.—At the right nostril, a small quantity of a slimy, putrid secretion is apparent. Disagreeable smell.

Jan. 8, 1902.—Typical chronic nasal catarrh is present. Mucosa of the mouth is pale. Under the tongue, an irregular croupous membrane is located, about 1 mm. thick. This membrane was difficult to remove, and after removal the surface beneath bled.

Jan. 9.—An extended new membrane has formed at the old place. It was again removed, and cultures were made from the mucous membrane lying beneath the false membrane, from which the roup germ was subsequently isolated.

Jan. 10 to Feb. 10.—Nasal catarrh remained chronic and putrid. The croupous membrane disappeared after having reappeared after four daily removals. Later, several small membranes appeared at different places in the mouth.

April 24.—The discharge from the nose has disappeared for 8 days, and there is no disagreeable smell. All visible mucous membranes are extraordinary pale. General condition, normal. No apparent loss of flesh during the disease.

Fowl No. 13. Healthy hen, about 8 months old.

Jan. 10, 1902.—½ c.c. of a bouillon culture, made from parts of the epithelial membrane under a removed croupous patch of diseased chicken 9, was subcutaneously inoculated. The culture was not pure, but the most numerous germ was the roup bacillus. At the place of inoculation, a hot tumor appeared, and became slowly resorbed in a few days.

Fowl No. 4. Weak hen, about ½ year old.

Jan. 12.—Inoculated in the mouth with an anaerobic bouillon culture, 48 hours old, made with the same material from diseased chicken No. 9. It contained coli and roup bacilli, and a streptococcus.

Jan. 13.—At the place of infection in the mouth, two small white spots have formed.

From 14th of Jan. till 10th of Feb.—General condition, normal. Several times, small croupous spots formed on the mucous membrane in the mouth for a few days.

Fowl No. 18. Healthy young hen.

Jan. 12.—Was inoculated with an aerobic culture from diseased hen No. 9 in the mouth and under the right conjunctiva. This culture contained the roup bacillus, and some long and thick rods, and a few cocci.

Jan. 14.—The infected eye-lid is slightly swollen. Mouth, normal.

Jan. 15th till Jan. 23rd.—General condition always normal. Swelling of the eye-lid disappeared. Mouth never affected.

Fowls 22 and 23. About 6-month-old hens.

Jan. 21.—A young agar culture of the roup bacillus, isolated from fowl 3, was inoculated in the mucous membranes of the mouth and nose without any abnormal changes subsequently taking place.

Fowl 26. Healthy hen, 1 year old.

Had suffered from natural roup at the beginning of winter, but wholly recovered after being diseased for two months.

March 15.—¼ c.c. of a young culture of the roup bacillus, isolated from an infected pigeon, was inoculated in the left superior eye-lid, and in the pleural cavity.

March 16.—General condition very much disturbed. Eyes were kept shut, left eye-lid swollen, and warm. The conjunctiva is very watery, and grey. Under the eye-lid, there is much slimy matter. The bird breathed through the beak with loud inspiratory noise.

March 17.—General condition much improved. Respiration through the beak, swelling in the eye-lid diminished. Killed by decapitation.

Post-Mortem : Carcass in a fairly well nourished condition. Conjunctiva, pale and watery. In the depth of the submucous tissue of the left eye-lid, a solid mass of grey pus, about 1½ cm. long, is found. It can be extracted without breaking, being surrounded by a smooth brown membrane. At several places in the periorbital tissue, similar pus masses are present, but was sharply separated from the surrounding tissue. The interior eye is in tact. The nasal mucosa in the regio olfact. is highly reddened and covered with much slimy putrid secretion. In the mucous of the left lacrymal canal are small bloody extravasations. Lungs are oedematous.

Fowl No. 27. Small healthy hen, about one year old.

Had several times been inoculated with the roup bacillus without result. On the 28th of April, this bird was again inoculated with a young agar culture of the roup bacillus, which had been passed through two pigeons. ¼ c.c. was injected into each of the upper eye-lids, and 3 c.c. in the right pleural cavity.

The next day, the eye-lids were swollen, and the general condition of the fowl was disturbed. In a few days, all pathological symptoms had disappeared .

Fowl 28. Large strong hen, about 1½ years old.

Had been diseased with roup at the beginning of the winter, and entirely recovered.

March 15.—Was inoculated with 1½ c.c. of a 24-hour-old roup culture in the right pleural cavity, and ¼ c.c. under the conjunctiva of the right eye.

March 16.—General condition disturbed. Small swelling of the eye-lid.

March 17.—Condition, normal.

April 14.—Subcutaneously inoculated with a 5 c.c. of a culture of the roup bacillus near the sternum.

April 15.—General condition, normal. Locally no change.

April 22.—5 c.c. of a 24-hour-old roup culture again subcutaneously inoculated.

April 23.—General condition much disturbed. The bird is apathetic and mopes in a corner of the cage. Locally, no change.

May 1.—General condition still disturbed, with loss of flesh. All mucous membranes are pale ; no appetite.

The 14th of June, a stinking diarrhoea set in, and the fowl died on the 18th.

Post-mortem examination showed many grey, solid nodules in both lungs, and a slimy catarrh ; at other places, a hemorrhagic inflammation of the thicker bowels.

Fowl No. 29.—Young hen which had been affected with roup in the early winter ; healthy when inoculated.

March 16.—Inoculated in mouth and eye-lids with a culture of the roup germ, which had been passed through pigeons.

March 17.—Eye-lids considerably swollen, and hot. On the right side there is a serous secretion from the conjunctiva. Conjunctiva is grey, swollen and soft. General condition, highly disturbed.

March 19.—In the depth of the right upper eye-lid, a solid round tumor has formed. It is neither in direct contact with the mucosa or cuticle of the eye-lid, both being movable upon it. Conjunctiva, grey-brown in color. Slimy, putrid catarrh of the conjunctiva. The left upper eye-lid is but slightly swollen, and no conjunctival catarrh exists. General condition, very much disturbed. Bird apathetic, with almost no appetite.

March 20.—The tumor in the right eye-lid is better, and symptoms of acute inflammation have disappeared. Secretion of the conjunctiva is slimy and putrid. General condition, much better.

March 21.—Dead.

Post-Mortem : Carcass fairly well nourished. The solid tumor in the right upper eye-lid consists of a firm mass of pus, 2 cm. long, ½ cm. wide, and 2 mm. thick ; color grey. It can be easily extracted, being surrounded by a dirty grey, smooth membrane. Conjunctiva is grey, and uneven. In the submucous tissue of the left upper eye-lid, there are a few grey layers of pus, not surrounded by a membrane, as in the right eye-lid. The inner eye and other organs unchanged.

Fowl No. 30. Healthy hen, about 2 years old, had been diseased with roup at the beginning of the winter ; but apparently healthy when inoculated.

March 17.—Was inoculated with the solid matter (suspended in sterile water) from the eye-lid of fowl No. 26. A few drops were injected into the right upper eye-lid, 1 c.c. in the right thoracic cavity. The solid matter contained leucocytes and roup germs.

March 18.—Small swelling of the eyelid, without pathological scretion of the mucous membrane. General condition, very much disturbed.

March 20.—General condition, better. Sometimes the hen coughs. Swelling in the eye-lid mostly disappeared.

Later, the fowl recovered entirely.

Fowl No. 31. Had been diseased before. Inoculated in the same manner as fowl 30. After 24 hours, the general condition was very much disturbed, the eye-lid swollen, but the bird recovered in a few days.

Hen No. 32. Hen, gray, about one and a half years old. Had suffered with natural roup till New Year. Healthy now.

March 19.—Inoculated with a small quantity of the cheese-like matter from pigeon 12 (which had been inoculated with the roup bacillus) on the mucous membrane of the mouth and in the pleural cavity.

March 20.—General condition disturbed. A croupous membrane has formed in the mouth, about ¼ cm. in size and 1 mm. thick. It can easily be removed. The mucous membrane under it is uneven and grey.

March 26.—General condition, better. At several places in the mouth cavity, small pseudo-membranes have formed. Appetite lacking.

April 8.—Great loss of flesh. General condition, very bad. Fowl generally lies on the ground and does not care for food. Killed.

Post-Mortem: On the left side is a chronic indurative pleuritis (pleura thick and uneven, gray); liver small, spleen very large, without germs. The interior of the thin bowels contain a little food mixed with much slime. In the mucous membrane are petechial spots at many places.

Fowl No. 33.—Small hen, about 2 years old, had been diseased with roup. Was inoculated like fowl 32. Only a quickly passing disturbance of the general condition was the result.

Fowl No. 34.—Large, healthy hen that had never been diseased, about 1½ years old.

March 24.—Inoculated with agar culture (28 hours old) isolated from pigeon 20 (second passage through pigeons). The culture was rubbed in the mucous membrane of the mouth, and 1-8 c.c. was injected under the mucous membrane of the upper eye-lids.

March 25.—General condition disturbed. Hen takes no interest in its surroundings, but cowers in a corner of the cage, with the neck drawn close to body, and eyes shut. The right, upper eye-lid is considerably swollen, and has its skin reddened. Conjunctiva gray. The left upper eye-lid is slightly swollen. Mucous membrane in the mouth is pale. Several yellowish-white pseudo-membranes are located on the tongue, and the mucous membrane near it. The submucous tissue on the bottom of the mouth cavity is oedematous.

March 26.—The oedema under the tongue has increased and spread over the face, up towards the eyes. The right eye-lids are sticking together, and cannot be opened. On the mucous membrane of the pharynx are several pseudo-membranous spots. The whole mucous membrane in the mouth is covered with clots of saliva.

April 2.—General condition improved. The right eye is always kept shut, and the lids are sticking together. Beneath the eye-lid there are putrid, slimy masses, and conjunctiva is dirty gray. The upper eye-lid is much swollen, the swelling having extended especially towards the nostrils.

April 8.—Condition the same. On the conjunctiva of the right upper eye-lid, a croupous membrane is located, yellowish-white, uneven, 2-3 mm. thick, and about ¼ cm. in size. It can be removed. The mucous under it is uneven, gray and begins to bleed at several places. The oedema under the tongue has become absorbed. A small pseudo-membrane has formed on the palate near the entrance to the nasal cavity

April 10.—General condition very bad. The fowl cowers in a corner of the cage, and pays no attention to its surroundings. It kepes its eyes shut, and the feathers are in great disorder. The appetite is very poor, and the whole face is much swollen. The wattles are swollen and prominent.

April 13.—General condition is improved. The purulent secretion from the right eye has diminished. The swelling of the face still exists. At several places fluctuation can be noticed ; at others, an emphysema.

April 16.—The whole tumor is less hot, and is in an emphysematous condition. The tumors in both upper eye-lids are in communication with the tumor of the whole face. A croupous membrane still exists on the palate.

April 24.—General condition very bad. The hen lies most of the time on the floor of the cage in a comatose condition. The local changes have remained as they were, but the purluent conjunctivitis on the right side has almost entirely disappeared

April 26.—Dead.

Post-Mortem : Carcass almost destitute of flesh and fat. Mouth and nares seemingly normal. Spleen a little swollen. In the subcutaneous tissue of the head there is a putrid abscess, the pus is dark brown, liquid, mixed with solid cheesy masses, and stinks offensively. The walls of the abscess are formed by a pyogenous membrane, which is covered with a solid layer of cheese-like, dry matter, having the appearance of the pseudo-membranes in the mouth. The roup bacillus was found in the pus, together with large numbers of coli-like bacteria. The spleen contained some coli-like bacilli.

Fowl No. 35.—Healthy hen, about one year old, which had never had roup. It was inoculated with the same culture as fowl No. 34.—two drops in the upper eye-lid of the right eye, and two drops into the high parts of the nose, the needle of the syringe being thrust through the dorsal wall of the nose.

March 24.—General condition much disturbed. Swelling of the right eye considerable, hot and firm, and the skin reddened. In the eye-lid, large quantities of slimy lacrymal secretions are present. Conjunctiva gray and swollen. Two small pseudo-membranes are located on the Conjunctiva of the upper lid.

The right nostril is covered with dirty gray, partly dried secretion. Under the tongue a croupous membrane has formed, being about ¼ cm.2 in size.

March 26.—General condition bad. The hen lies on the bottom of the cage in somnolent state ; occasionally it wakes up, rises and walks around, taking some food or water. The tumor in the right eye-lid has grown down the face as far as the wattles. It is soft and hot. The eye-lids are sticking together. By opening them, a large quantity of a purulent secretion exudes ; and a clear jelly-like mass about one c.c.m.2 in size, can be removed from the depth of the eye-lid. A pseudo-membrane, about 2-3 mm. thick, has formed on the conjunctiva at the bulbus oculi, just over the cornea. On removal, the mucous membrane beneath begins to bleed. The membrana nicticans is greatly swollen. On the interior side a pseudo-membrane has formed about 4 mm. in size. The pseudo-membrane in the mouth has increased in thickness and size. A purulent secretion exudes from the right nostril.

March 27.—General condition, better. The membrane on the bulbus oculi has reformed and the jelly-like mass in the lid sack has reappeared, but is now turbid and gray.

March 28.--The secretion from the nostrils smells offensively. The right eye-lids are again sticking together, and the eye-lid contains a jelly-like, grayish mass

March 29.—General condition is very bad. The eye-lids are sticking together and bulge out, because a yellowish-white, solid cheesy mass fills the whole eye-lid. This mass has formed from the jelly-like mass, which had been removed yesterday.

April 1.—Dead.

Post-Mortem: Fairly well nourished carcass. Left eye normal. The right eye-lid diffusely swollen. Between the partly opened lids a cheesy tumor protrudes (See Fig. N. 11). It fills the whole eye-lid and can be removed by pressing on the eye-lids. The conjunctiva gray and uneven. On the upper eye-lid a small pseudo-membrane has formed ; similar membranes are located on the outside and inside of left eye-lid. Small masses of solid yellowish matter can be found in the subcutaneous tissue of the upper and lower eye-lid. The nasal cavities are blocked up with cheesy yellowish-white matter. The right infra-orbital cavity is filled up with the same cheese-like substance. On account of the pressure of this mass, the lateral bone-wall has disappeared, and the cheesy mass lies directly under the skin of the face. The mucosa of the nares is grey and very soft. The mouth contains sticky masses of saliva ; spleen and liver are small and normal. Cultures made from portions of these organs remained sterile.

Fowl No. 36. Young healthy hen.

March 24.—Was inoculated like fowl No. 35, in the nose and right eye.

March 25.—General condition is considerably disturbed. Eye-lids swollen, conjunctivitis, on the upper lid is a small croupous membrane. Nostrils are dirty. A small quantity of yellowish-white liquid can be pressed out of the right one.

March 26.—The pseudo-membrane on the eye-lid has spread upon the bulbus oculi. It is about 1-2 mm. thick, and was removed. The mucous membrane under it is grey and uneven. Several small thin membranes have appeared near the tongue.

March 27.—The membrane in the eye has reformed. General condition improved.

April 2.—A solid, smooth tumor has formed in the depth of the right upper eye-lid. It has extended towards the nostrils.

April 15.—Chronic, putrid conjunctivitis. Eye-lids often sticking together. Croupous membranes of the Conjunctiva always reappear after removal. Small pseudo-membranes often appear in the mouth. General condition disturbed with loss of flesh. Killed.

Post-Mortem : Eye-lid contained gray, slimy masses. Mucous is uneven. A cheesy membrane, about one cm.2 in size and two to four mm. thick covers the mucosa of the upper eye-lid. (Fig. 9). It adheres firmly to the mucosa, and is directly connected with solid, cheesy matter in the depths of the eye-lid. The mucous membrane of the nares shows a few small, bloody extravasations. Other organs are normal.

Fowl No. 37. Healthy, young hen which had had roup in the early winter. Inoculated like Fowl No. 36 in the left eye. After 24 hours, the eye-lid was swollen. Later a heavy, putrid catarrh of the conjunctiva set in, and pseudo-membranes formed several times on the conjunctiva. The general condition was more or less disturbed, and the appetite normal.

April 11.—The posterior half of the cornea was covered with an irregular pseudo-membrane, about 1½ mm. thick, yellowish-white, the other half clear, with the exception of a small turbid border near the pseudo-membrane. At the same time, the conjunctival secretion smelt offensively.

April 12.—A great part of the pseudo-membrane had disappeared, leaving the cornea uneven and gray. Two small membranes have formed on the upper eye-lid. At the place where the cornea had been covered by the pseudo-membrane, an ulcer developed, grew deeper and deeper, and opened on the 17th of April into the anterior eye cavity. The lens fell prolapsed and grew together with the perforated cornea. The cornea wound soon became filled up with a gray granulated tumor, which regenerated slowly.

The general condition was very much disturbed, and never again became normal.

On the 1st of May, the general condition was very bad. All visible mucous membranes were very pale. The swelling in the eye-lids and the conjunctival catarrh have disappeared, but the hen was blind. Death occured on the 4th of June.

Post-Mortem : The Post-mortem examination showed all symptoms of severe anaemia. The corpora vitrea were partly softened, the retina split in many places and portions of the retina were mixed with the liquefied corpus vitreum.

Fowl No. 38. Hen about two years old.

April 3.—Was inoculated with virulent Roup bacillus, 1-5 c.c. under the conjunctiva of the right eye, and on the scratched mucous membrane of the mouth.

April 4.—The eye-lids were inflamed, hot and sticking together. Under the eye-lid, there is much slimy lacrymal secretion, and a jelly-like mass. The places of inoculation in the mouth are covered with thin pseudo-membranes. General condition disturbed. Later on, several small croupous membranes formed on the mucous membrane in the mouth.

April 11.—The whole eye-lid was filled with a cheesy, solid mass, which could easily be removed. Conjunctiva dirty gray. On the upper eye-lid a fairly large pseudo-membrane has formed. The next day the cheesy mass had reformed larger than before.

April 24.—A large solid tumor has formed in the depth of the upper eye-lid. The pseudo-membrane could scarcely be removed. Later, the putrid conjunctival catarrh ceased, the pseudo-membrane disappeared, the tumor in the eye-lid remained unchanged. The general condition was slightly disturbed, and the hen lost flesh.

Fowl No. 39. Inoculated with a Roup culture, which had been passed twice through pigeons, but then cultivated on agar for three weeks. The eye-lids became swollen, but the swelling soon subsided. General condition remained normal. The culture, therefore, had lost most of its virulence.

Fowls No. 42-45. Healthy young hens, inoculated with freshly isolated, virulent Roup bacillus, on the mucous membrane in the mouth. Everywhere croupous membranes appeared at the places of inoculation. There they remained for a few days, and generally reappeared after removing once or twice.

The most severe reaction occurred in fowl 43 the day following the infection ; the general condition was very much disturbed, the beak was kept open, and much saliva was found in the mouth. The palate was covered with a whitish croupous membrane. Other membranes were located in the pharynx.

The last pseudo-membranes disappeared in all these infected fowls in two or three weeks.

## Pigeon Inoculations.

Pigeon No. 1. This bird was inoculated in both eye-lids, and on the mucous membrane in the mouth, with cheesy matter taken from the wattles of diseased fowl No. 24.

Feb. 18, 1902.—The only result was a swelling of the eye-lids, which quickly disappeared.

Feb. 27.—Condition normal. . Some croupous membrane taken from a diseased fowl was rubbed on the mucous membrane of the pigeon's mouth, and on the conjunctiva.

March 4.—Normal. Inoculated ¼ c.c. of a culture of the roup bacillus, which had been grown for several months on agar. The next day the bird was weak and somnolent, with no appetite. Both eyes are kept shut, the eye-lids sticking together ; conjunctivitis.

April 17.—The acute conjunctivitis generally became chronic and putrid, but disappeared after a while. No pseudo-membranes formed on the conjunctiva, but several of them appeared on the mucous membrane of the mouth for several times. The general condition was better.

Inoculated 2 drops of a roup culture (24 hours old) in the left conjunctiva on the upper eye-lid, and into the mucous membrane of the mouth.

April 18.—General condition very much disturbed ; eye-lids sticking together, and swollen. The lid-sack contains slimy tears. A whitish pseudo-membrane has formed on the palate. Inoculated 3 c.c. of a filtered (sterile) bouillon culture under the skin.

April 19.—Condition like yesterday. The filtered culture has been entirely absorbed.

April 28.—The chronic catarrh of the conjunctiva still exists. In the depth of the upper eye-lid, a solid tumor has formed. Good general condition.

Pigeon No. 4. This bird was inoculated on the 18th of February with cheesy masses, taken from the lungs of fowl 41 (B. pyocyaneus), on and in the mucous membrane of the eye and mouth.

Feb. 25.—General condition, not disturbed. The day following the infection, small croupous membranes formed at several places in the mouth. The whole palate is covered with a yellowish-white diphtheritic membrane which was difficult to remove ; the mucous membrane was uneven, gray and bleeds. The eye-lids are slightly swollen.

March 6.—The pigeon is apparently normal. ½ c.c. pure culture of the roup bacillus was inoculated into the left pleural cavity.

March 8.—General condition very badly disturbed.

March 13.—General condition has slowly improved. All mucous membranes are very pale. On the palate, a small croupous membrane has formed. Killed.

Post-Mortem: Left lung is firmly adherent to the pleura. The central part of the lung, that is, the region of the branching off of the larger bronchial tubes from the wind-pipe are solid, and inflamed. In the centre of this inflamed area is a solid, dry cheese-like, yellowish-white mass, measuring about 1 c.c. in diameter. This mass is partly surrounded with a smooth red-brown membrane. Spleen is small, and cultures made from it remained sterile.

Pigeon No. 3. Inoculated the 18th of February in the same manner as pigeon 4, and in addition 1 c.c. of the cheesy mass, triturated in sterile water, was injected in the left pleural cavity. The general condition was very much disturbed for the first 3 days after inoculation. The eye-lids were swollen, and a few small croupous membranes appeared in the mouth.

Feb. 27.—Condition normal. Some of the mucous membrane from fowl No. 27 was inoculated, after trituration in sterile water, into the mucous membrane of the eyes and mouth. No reaction followed.

March 6.—1-5 c.c. of a culture of the roup bacillus was injected into the left upper eye-lid. The eye-lid became very much swollen, and an acute serous conjunctivitis developed, and became slimy and putrid. A solid tumor formed in the swollen eye-lid. The general condition was much disturbed at the beginning and slowly became better.

May 6.—General condition normal. Local conditions have disappeared with the exception of a solid tumor in the upper eye-lid.

Pigeons No. 5, 6, 7, 10, and 11. These birds were inoculated in the mouth and eye-lids with about 1-5 c.c. of a bouillon culture of the roup bacillus, which had been growing on artificial media for about two months. The only results were slight swelling, which generally disappeared after a few days. They were inoculated again with the roup bacillus, which had been previously passed through two pigeons. Local swelling followed the injection, with putrid, chronic catarrh of the conjunctiva, and diphtheritic membranes in the mouth.

In pigeon No. 5, on the 20th day after the infection, a bad swelling, with putrid catarrh of the nostrils, set in, and remained until death occurred. The tumor in the left upper eye-lid grew down towards the nostrils. The side of the face became very much swollen, hot and painful. After a while, the centre of the tumor became solid, and the left half of the palate began to grow down into the mouth cavity. At the lateral side of the palate, croupous membranes appeared, and always reappeared afer removal. At other places in the mouth and pharynx, similar membranes appeared. The general condition of this bird was always disturbed. It lost most of its flesh, and died the 14th of April. (Second inoculation had taken place on the 9th of February).

Post-Mortem : A putrid chronic conjunctivitis is present. The tumor on the left side of the face is formed by a solid yellowish-white cheesy mass, lying just under the skin. This cheesy mass protrudes into the infra-orbital cavity, and also fills the nasal cavities. The tumor had pressed down the left part of the palate towards the mouth cavity and cause a total absorption (by pressure) of the bone at the lateral edge. Here, a thick yellowish cheese-like pseudo-membrane had formed, and this was in direct contact with the cheesy matter in the infra-orbital cavity. The lower parts of the nasal cavity contained a little putrid, slimy secretion, which had an offensive smell.

In Pigeon 6, a putrid catarrh of the nares appeared the 6th day after the second infection (19th of March). The left palate began to be pressed down towards the mouth. On the 11th day (24th of March) both nostrils were entirely closed with dried secretions, and the bird kept its beak open for breathing. The left eye was shut, the lids sticking together. On opening the lids, a putrid, slimy secretion, containing many solid, cheesy masses, could be pressed out. The anterior part of the cornea was covered with yellowish, uneven pseudo-membranes. This was removed, and the remaining cornea had the appearance of a cancer. It was soon covered again with a pseudo-membrane.

The general condition had not been very much disturbed at the beginning, but grew worse towards death, which occurred the 27th of March, that is 15 days after the second, or 39 days after the first inoculation. (See Fig. 8).

Post-Mortem : Carcass in poor condition. Nostrils and left eye are covered with dirty, offensive smelling secretions. The left conjunctival sac contains a slimy, putrid, lacrymal secretion, and a solid, cheesy mass. Conjunctiva is gray and uneven. Only a small part of the cornea, the posterior edge, has a normal appearance, the other part beng covered with a pseudo-membrane, which had spread upon the surrounding conjunctiva. No turbid zone between diseased and healthy cornea exists. Under the pseudo-membrane, the cornea has the appearance of a cancer. A solid yellowish, cheesy mass was extracted from the left upper eye-lid. There was also a little tumor under the lower eye-lid. The infra-orbital cavity is filled with cheesy matter. The palate is pressed down towards the mouth cavity. The mucous membrane of the nares is gray and swollen. The nasal cavities are filled up with a stinking, putrid, slimy secretion. A small pseudo-membrane is located in the pharyngeal membrane. Liver is enlarged ; spleen small, and contains a few coli-like bacteria.

In Pigeon No. 7 no nasal catarrh set in. The putrid secretion from the left eye smelt offensively. Conjunctival catarrh and swelling of the eye-lids had disappeared in six weeks. Inoculated a third quantity of a virulent culture, with the same severe reaction as with the second.

Pigeon No. 10 suffered from a severe putrid catarrh of the conjunctiva for two months after the inoculation. In the latter stage of the disease, severe diarrhoea set in.

Pigeon No 11 had been inoculated the second time with 1 c.c. in the pleural cavity, and with a few drops in the right upper eye-lid. General condition was very much disturbed at the beginning ; later, it became better, only to become worse again. A putrid catarrh of the right conjunctiva developed, and a solid tumor formed in the depth of the upper lid. 7 days after the second infection the pigeon was dead. (23rd of March).

Post-Mortem : From the eye-lid, much solid, cheesy matter was extracted. The conjunctiva was gray and swollen ; the cornea turbid, but smooth ; the corpus vitreum was partly liquefied, turbid, and contained pieces of the destroyed retina ; the periorbital tissue has a few gray spots of pus. The central part of the right lung is completely congested, red, and contains a small, putrid centre. The pus was liquid, with an offensive smell.

Pigeon No. 15. This case was similar to that of Pigeon No. 11. The bird died 5 days after the second inoculation.

Pigeon No. 9. Was inoculated with a virulent culture of the roup bacillus by rubbing this on the mucous membranes of the mouth and nostrils. (5th of March).

Small croupous membranes appeared in the mouth. General condition was much changed. Five days later the pigeon was killed.

Post-Mortem : The lower parts of the nasal cavity contained much putrid secretion. The left infra-orbital cell was filled up with a solid, cheesy mass. The mucosa of the nose was gray, with small blood extravasations at several places ; a cheesy mass had formed, in the submucous tissue underneath the tongue. Near this place, the mucous membrane bears a small diptheritic spot.

Pigeon No. 12. Was inoculated 14th of March with a roup culture (freshly isolated from the nares of fowl No. 23), in the mouth, nose and pleural cavity. General condition was a little disturbed the next day, when a croupous membrane formed between larynx and base of the tongue. Later on, other pseudo-membranes appeared.

March 18.—Near the left angle of the beak, a new croupous membrane has formed, and the left nostril was partly blocked up, with an offensive, gray secretion. General condition bad. The bird lies most of the time on the bottom of the cage in a somnolent condition.

March 19.—Dead.

Post-Mortem : The central part of the right lung was inflamed. This lung contained two, small pneumonic spots. All other interior organs were normal, the spleen containing but a few colon bacilli. The nasal cavities were filled up with a slimy, gray offensive secretion, which contained many cheesy masses. The left infra-orbital cavity was full of a yellow, cheesy matter, which was in direct contact with an extensive pseudo-membrane on the palate and left side of the mouth cavity.

Pigeon No. 13. Was inoculated with roup bacillus like pigeon No. 12. The general condition was disturbed. Six days after the infection, the pigeon was killed.

Post-Mortem : Nares apparently normal. Under the tongue, 2 small pseudo-membranes have formed. The submucous tissue contains a solid, cheesy mass, about as large as a hazel nut.

Pigeon No. 14. Was inoculated with a roup culture which had been growing in bouillon for 4 weeks. 1-5 c.c. was injected into the conjunctiva of the upper eye-lid and mouth. The general condition became disturbed. The eye-lids became swollen, and a solid tumor formed in it. This tumor began to get soft again after two months, and finally showed typical fluctuation. Size of the tumor, about 2 c.m.2. Two and a half months after the infection (14th of April), the pigeon was killed.

Post-Mortem : The tumor in the eye was caused by an abscess. The centre contained liquefied, putrid, gray pus. The walls were formed by a solid cheesy matter, which again was surrounded by a pyogenous membrane.

Pigeon No. 16. Was similar to pigeon No. 14.

Pigeon No. 23. Was inoculated with a virulent roup culture. The general condition was considerably disturbed. Small croupous membranes formed on the mucous membrane in the mouth. Five days after the infection (14th of April), a serous catarrh of the left nostril became apparent. Two days later, the pigeon had a very offensive smell. These symptoms disappeared after a few days, and the pigeon recovered.

## Resume of Inoculation Experiments.

Reviewing our experiments with the 24 chickens, we see that to produce a typical case of roup, it was necessary to use a freshly isolated roup bacillus culture (fowl No. 3). Fowls 22 and 23 had been inoculated with the same culture grown for some time on artificial media. This caused considerable loss of virulence and failed to produce the disease.

Fowls 13, 17 and 18 were inoculated with young cultures from some of the diseased parts of naturally infected fowls. These were not pure roup cultures, and their effect upon the chickens was only a slight one. By passage through pigeons, however, the roup bacillus was made more virulent. The bacillus was usually isolated on agar or gelatine plate cultures.

The fowls 26. 28-33 were infected with a culture passed through one pigeon. These fowls had been suffering from natural roup in early winter, but at the time of their inoculation were quite healthy. Four out of the six became diseased, while the rest showed only passing symptoms and disturbances.

A second series of experiments was carried on with roup cultures which had been passed through two pigeons. The chickens concerned in these experiments are No. 34-39 and 42-45. One of them, i.e., fowl 39, was infected with a culture which had been grown on artificial media for three weeks, after isolation from the second pigeon ; in this case the bird was only very slightly affected. In all the other fowls, the cultures were used as soon as possible after isolation from the last pigeon. All reacted with pronounced symptoms comparable to those of a natural attack of roup. Two cases ended in death in five and thirty-three days respectively. Two lead to chronic loss of flesh and were anaemic. Fowl 36 was killed after a bad attack which lasted 22 days. The other diseased fowls recovered in 3 or 4 weeks.

The virulence of the roup bacillus might be made even more virulent by passage through a longer series of pigeons.

The pigeons themselves can be infected with the roup bacillus and show symptoms identical with those in chickens, but we seldom hear of pigeons suffering from roup under natural conditions, but they may become diseased as has been proven by these experiments. Very probably, they are more resistant against the natural channels of infection, being kept in relatively healthier localities than the average flock of farm chickens.

Fowl No. 27 could not be infected even with large quantities of the virulent cultures of the roup bacillus. It seemed to possess a natural immunity to roup.

Subcutaneous injections of 1-8 c.c. to ¼ c.c. cultures of the roup bacillus caused only slight disturbances of the general condition. The skin was often colored green about 24 hours after the injection, and occasionally small solid tumors (solid pus) formed. Larger quantities (2-5 c.c.) of the culture caused large tumors, which were hard and painful at the beginning ; later, a hard solid, smooth or uneven, tumor formed in the depth (similar to the effect on the eye-lids), when the symptoms of acute inflammation disappeared, the solid tumor remained as a foreign body for months ; and the fowl lost flesh, became thinner and thinner, anaemic, and often died in from two to six months after inoculation, or recovered very slowly. The solid tumors are nothing but a mass of solid cheesy pus (see fowl 40 and pigeon 5).

Injected into the muscles, the roup bacillus causes extended necrosis of the tissue, which smelt offensively.

In the pleura and peritoneum,putrid inflammations are produced,from which the fowls may recover, but often die after a chronic disease (anaemia) lasting from 2 to 12 weeks.

Two chickens and two pigeons were fed with cultures of the roup bacillus mixed with their food, and no bad results followed.

Fowls and pigeons once infected with roup could be infected a second time after recovery from the first attack. Birds which had suffered from a natural attack of the disease and then recovered, also became again infected by the inoculation of the Roup bacillus ; and finally serum from naturally or artificially infected birds did not show any apparent influence on the roup bacillus. In test tubes, traces of an agglutination appeared in proportions of 1:50 or 1:100. The bacillus does not form a strong toxin. Old cultures filtered through porcelain inoculated in doses of 3-6 c.c. produced no local or general disturbances.

Bouillon cultures heated to 65 degrees c. for 10 minutes and inoculated in doses of 1-4 to 1 c.c. into the eye-lids of healthy fowls produced considerable inflammation, which disappeared in 2 days. 2-5 c.c. inoculated into the pleural or peritoneal cavity disturbed the general condition for 1 to 3 days, and produced trembling of the muscles.

We attempted to immunise several fowls and rabbits with the roup bacillus, first injecting small quantities of heat killed cultures, followed by small doses of living cultures. The amount inoculated was slowly increased, but as soon as we began to use large amounts, small tumors formed beneath the skin. These became solid, hard, and had no tendency to become absorbed or to produce abscesses. They remained under the skin and led to chronic anaemia and death of the animal. After intraperitoneal injection of the cultures, the animals became chronically diseased, and grew thin and anaemic. The rabbits very often suffered with a secondary, putrid inflammation of the eyes.

These attempts to produce immunity were finally abandoned, as it seemed impossible to produce immunity by the methods described above.

### Experiments to Infect Healthy Fowls with Bacilous Pyocyaneous.

Fowl No. 41. Healthy hen, about 1 year old.

Jan. 12.—Was inoculated with a 24-hour-old culture of B. pyocyaneus which had been isolated from diseased chicken No. 19, by rubbing a little of the culture upon the mucous membrane of the eyes, and injection of 1½ c.c. into the pleural cavity.

Jan. 13.—General condition considerably disturbed. There is hot swelling of the left eye-lids, serous conjunctivitis. Conjunctiva is gray, swollen, and at several places covered with croupous membranes, which are easily removed.

Jan. 26.—General condition more or less disturbed ; no appetite ; putrid conjunctivitis of the left eye ; the cornea is turbid, gray, and uneven ; the beak is generally kept open for breathing. Mucous membrane is gray and covered with much slimy saliva.

Feb. 17.—General condition is very much disturbed. The fowl is almost a skeleton, and lies in a corner of its cage in a somnolent condition. The respiration, especially the inspiration is very irregular. Mucous membrane and crest are cyanotic. A chronic, putrid conjunctivitis exists on the left side. Cornea gray; right eye seems to be normal, but the fowl is unable to see. Killed.

Post-Mortem : Left cornea is uneven, gray, and covered with a thin, putrid mass. The corpus vitreum is turbid, partly liquefied, and mixed with parts of the destroyed retina. A solid mass of cheesy matter has formed in the pleural membrane between heart and lungs, and the surrounding membrane is changed into a thick mass (2-3 mm.) of granulation tissue of a brown color. On the left side, all bronchial tubes in the region of the larger branches of the wind-pipe are filled with solid cheesy matter. The lungs themselves contain a few small pneumonic spots, which contain cheesy centres. The B. Pyocyaneus was isolated from all diseased parts. The cheesy mass itself contains nuclei of epithelial cells and a few real protozoa, motile, with short cilia (see Fig. 21.).

Fowl No. 41a. Was inoculated on the mucous membrane of the mouth and nose with the same culture as fowl 41. The next day (February 13th), the mucous membrane in the mouth was reddened, and showed a few blood-extravasations. These symptoms soon disappeared.

Fowl No. 46. Healthy, gray hen.

April 18.—Was inoculated with 1-5 c.c. of a young culture of B. pyocyaneus under the conjunctiva of the left upper eye-lid, and on the scratched mucous membrane of the mouth.

April 19.—General condition unchanged. Eye-lids hot, swollen, and sticking together. Conjunctival sack contains a slimy, putrid secretion. Mucous membrane in the mouth is gray and covered with slimy saliva.

April 21.—On the conjunctiva of the upper eye-lid, a pseudo-membrane has formed. It was removed, and the mucous membrane began to bleed. Several other membranes have formed on the mucous membrane near the the larynx (1-2 mm. thick).

April 25.—The condition is about the same. Putrid conjunctivitis and appearance of pseudo-membranes. The membranes around the larynx reappear after removal. A putrid secretion from the right nostril has appeared. The general condition of the fowl is much disturbed, but appetite still exists.

May 2.—Dead.

Post-Mortem : Thin carcass. Mucous membrane in the mouth pale. Between tongue and larynx a cheesy croupous membrane has formed, which is easily removed. On the edge of the larynx, a few thick pseudo-membranes have formed. The laryngeal cavity is almost filled up with pseudo-membraneous, cheese-like masses. The membranes are either located on the mucous membrane, or directly on the cartilage. The mucous membrane is entirely transformed into croupous membranes (see Fig. 10). The upper eye-lid contains a solid cheesy mass, which was attached to the surrrounding pyogenous membrane by a few thin fibres. The conjunctiva of the same eye-lid is partly covered with a pseudo-membrane. The mucous membrane of the nostril is soft and covered with a putrid, slimy mass containing much solid cheesy matter. The nasal secretion has an offensive smell.

Fowl No. 47. Was inoculated on the 18th of April in the same manner as fowl No. 46. A putrid conjunctivitis formed. Diphtheritic membranes appeared in the mouth. The general condition was much disturbed at the beginning, but improved after a while. The fowl, however, grew thinner, became badly diseased again, and died the 25th of June. (See Fig. 7.)

Post-Mortem : The eye-lids were swollen, and the whole orbital cavity was filled up with a solid cheesy mass and offensive, stinking matter, the eye having disappeared.

Pigeon No. 29. The 14th of April, two drops of a young bouillon culture of B. pyocyaneus were injected under the conjunctiva of the left upper eye-lid. The next day the general condition was very much disturbed, the eye-lids swollen and sticking together. The eye-lids contained much slimy secretion and later two small croupous membranes had formed on the conjunctiva, the conjunctivitis became putrid, and the secretion smelt offensively. Often, pseudo-membranes appeared on the conjunctiva. A solid tumor formed in the upper eye-lid. The cornea was turbid. Subsequently, the bird recovered.

Pigeon No. 30. Was inoculated with 1 c.c. culture of B. pyocyaneus in the peritoneal cavity. Six hours later, it was dead.

Post-Mortem : The post-mortem examination showed an extended serous putrid peritonitis. The spleen was enlarged and cultures from this organ produced a pure culture of the inoculated bacillus.

From these few experiments with the B. pyocyaneus, it is apparent that this bacillus can produce chicken diphtheria in its different localizations in the mouth, eyes, nose, lungs, etc.

The virulence of the B. pyocyaneus is very soon lost by growing it in the ordinary culture media, but the virulence can be increased by passing it through several pigeons.

Reviewing the results of our experiments with chickens and pigeons, and comparing them with the symptoms of the natural disease, we conclude that chicken-diphtheria or roup is a complex of putrid processes, especially affecting the mucous membranes and the submucous tissues of the head. We could produce aseptic putrid processess in chickens by inoculation of sterile turpentine oil into the submucous tissue of the eye-lids, and always found the pus in the form of a solid, cheesy mass, which showed no tendency to become soft and liquid. Putrid processses in chickens seem to behave similar to those often found in rabbits, that is, the pus appears as a dry, cheesy, solid mass, not as a fluctuating abscess. (See the submucous and subcutaneous tumors in chicken-diphtheria).

In the cases of a severe putrid catarrh, the pus corpuscles often stick together, with the help of the abnormal secretion, from the mucous membranes or glands (note the jelly-like masses in the eye-lids), and finally become large, cheesy masses, which do not adhere to the diseased mucous membranes. (Cheesy masses in the nose, eye-lids, pleura, and peritoneum). In the mouth cavity, pharynx, larynx, and occasionally on the conjunctiva, the leucocytes, which passed through the mucous membranes, may remain adherent to these. Corresponding to the amount of transuded leucocytes and the degree in which the mucous membranes have been destroyed by them, or by accompanying fibrinous exudations, we observe pseudo-membranes of different severity and size.

The reason the transudated pus corpuscles remain attached to the surface of the mucous membrane in the mouth, and often in the eyes, too, but not in the nose, may be explained as follows: 1. The leucocytes have a natural tendency to stick together. 2. The described processes are very often accompanied by formation of pathological secretions (jelly-masses) in eyes and slimy saliva, or by fibrinous exudations between the cell elements of the epithelial tissue.

These two circumstances, especially the latter, produce the formation of pseudo-membranes. The third, and perhaps most important, reason is that the mucous membranes in the nostrils possess very many mucous cells, which mix their secretion products with the transudated leucocytes, and remove these from the epithelial surface. The conjunctiva, it is true, is not without mucous cells; but they are relatively scarce. Pharynx and mouth are without mucous cells, and, therefore, pseudo-membranes easily form in these locations.

Besides the two bacilli already described as causing the chicken diphtheria, other causal agents are more or less known ; thus, Loeffler described the Bacillus diphtheriae columbarum, Loir and Ducloux, the Bacillus diphtheriae gallinarum as causing diphtheria in fowls, and proved it by many experiments. Besides, there are protozoa, or corpuscles similar to protozoa claimed by other writers as the cause of fowl diphtheria.

All these results show that diphtheria in fowls cannot be a specific disease like the human one ; and, from this point of view, we have to consider the pathological symptoms. For example, the fowl diphtheria in Tunis, as reported by Loir and Ducloux, is differentiated from all other forms by the very acute character of the disease ; the presence of the infectious germs in all organs, secretions and excretions ; and the easy infection of healthy fowls with any parts of diseased ones.

European and American fowl diphtheria is especially a chronic disease, with very variable virulence, and severity of symptoms, which partly depends on the causal agent.

Roup or fowl diphtheria is generally brought into a healthy flock by a diseased fowl from another place, a fowl having suffered from a chronic attack of the disease (the more common form may be a catarrh of the nostrils or conchae and cella infra-orbitalis) during the summer suddenly becomes very ill again during the late autumn or winter; spreads the germs of the disease and infects the flock.

The third possibility is that in unhygienic locations, fowl diphtheria may appear without any preceding attack or importation of a diseased bird, the causal organism being very ubiquitous, for example, B. pyocyaneus. By means of the pathological secretions, the bacilli are spread throughout the whole fowl-yard. These germs may become more virulent by passage through one fowl to another. As the appetite is not generally altered at the commencement of the disease, water and food utsenils become infected with the causal organisms, and if these are sufficiently virulent, infection may take place by means of contaminated food or water ; but in all cases which have come under our observation, the first symptoms of roup generally appeared after common catarrh of the mucous membranes. The roup germs, therefore, seem to be unable to invade normal mucous membranes, but become a great danger to those affected by common colds. Poultry keepers know very well how exposed chickens and other fowls are to all kinds of colds by sudden changes in the weather. Young birds and individuals of the finer breeds are especially susceptible.

Fowl Diphtheria usually appears here with the unfavorable weather of the fall and early winter. In one night, a large number of fowls may become affected with catarrh, following which some fowls may become roupy, while others recover in a short time.

The experiments to transfer the disease by means of the pathologic secretions and excretions seems to contradict to a certain extent, our opinion about the way natural infection takes place. To explain this, we must bear in mind the fact that the causal organisms may be present in the pathologic secretions, etc., in large numbers, and in a very virulent form, whenever the germs are located on the surface, or in the highest layers of the epithelial membranes. (See fowl No. 8, and the result of isolating the bacilli from its pathologic products).

The Roup bacilli are not always localized in one place like the Klebs-Loeffler bacillus, which produces human diphtheria. The organisms causing Roup penetrate into the deeper and submucous tissues, and become the cause of phlegmonous processes and secondary catarrh of the adjacent mucous membranes and glands. In such cases, the roup bacilli are seldom present in the slimy, putrid secretions and pseudo-membranes. Further, the roup bacilli have often entirely disappeared from the pathologic secretions, or are mixed with many other bacterial species. This phenomenon occurs not only in chronic cases of natural infection, but also takes place in fowls which have been inoculated with the roup bacillus.

The pathological products themselves are sufficient, owing to their localization, their consistency, and the histological changes they cause, to produce the continuance of chronic catarrhs. Finally, as already stated the roup bacilli, enclosed in the cheesy masses, lose their vitality.

The fowls experimented with did not suffer from common colds, which must play an important part in the natural disease. As our experiments show, it is easier to infect healthy birds by keeping them a long time with diseased ones (5 out of 10 became diseased) than by direct inoculation of pathologic products on the experimental animals. The explanation of this is that fowls kept with diseased ones for a long time, are exposed to the possibilities of an infection, and at some time during this exposure the natural resistance of the bird is lowered, or some unfavorable condition allows infection to occur.

## References.

Babes und Puscariu, Zeitschrift fuer Hygiene, Bd. 8. 1890, S. 376.

Bollinger, Virchow's Archiv, Bd. 58. S. 349.

Brown, Poultry-Keeping, 1901. p. 109.

Chicoli, Sicilia agricola, 1884.

Cornil u. Megnin, Revue d'hygiene, 1884. S. 850.

Cornevin u. Nicati, Journal de medecine veterinaire, Lyon, 1879.

Corbett, The Poultry Yard and Market, New York, 1877. p. 88.

Dickson, Poultry: Their Breeding, Rearing, Diseases and General Management, London, p. 221.

Eberlein, Monatsheite fuer praktische Tierheilkunde, Bd. 5. 1895. S. 433.

Emmerich Revue d'hygiene, 1884. p. 850.

Ernst, Zeitschrift fuer Hygiene, 1888.

Ferre, Arch. clin. de Bordeaux, Bd. 6, 1877, p. 275. Nach Baumgartner's Jahresberichten.

Friedberger, Deutsche Zeitschrift fuer Tiermedizin u. vergleichende Pathologie, 1879. S. 161.

Friedberger u. Froehner, Lehrbuch der speziellen Pathologie u. Therapie der Haustiere, Bd. 2, 1900. S. 467.

Gallez, Deutsche mediz, Wochenschrift, 1896, Nr. 49.

Galli-Valerio, Centralblatt fuer Bakteriologie, etc., Bd. 22. 1897. S. 500.

Guerin, Annales de L'Institut Pasteur, 1901, Nr. 12. p. 941.

Johne, Bericht ueber das Veterinaerwesen in Koenigreiche Sachsen, 1880.

Konhaeuser, Monatschrift des Vereines Oestreichischer Tieraerzte, 1878.

Kitt, Bakterienkunde, u. pathologische Mikroskopic Wien, 1899. p. 180 und 410.

Krajewsky, Deutsche Zeitschrift fuer Tiermedizin und verleichende Pathologie, Bd. 13, 1887. S. 311.

Loeffler, Mittheilungen aus dem kaiserlichen Gesundheitsamt, Bd. 2, 1884. S. 482.

Loir u. Ducloux, Annales de L'Inst. Pasteur, 1894. p. 599.

MasFadyean & Hewlett, the British Medical Journal, London, 1899, 2, p. 1357.

Mazzanti, Osservazioni clinco-sperimentali sulla pseudo difterite da cercomonadi. Parma, 1896.

Moore, Investigations concerning infectious diseases among Poultry, Washington, 1895, p. 39.

Dawson, Annual Report of the United States Department of Agriculture, Washington, 1898, p. 352.

Neumann, Archiv fuer Kinderkrankheiten, Stuttgart, 1890.

Penzoldt, Deutsches Archiv fuer klinische Medizin, Bd. 42, 1887.

Perroncito, 11 Medico veterinario, 1886, p. 249.

Piana Galli-Valerio, Moderno Zooiatro, 1894.

Puetz, Oestreichische Zeitschrift fuer Vet. Wissenschaften, Bd. 1, 1887.

Pfeiffer, Zeitschrift fuer Hygiene, Bd. 5. 1889, S. 363.

Robinson, Poultry Craft, Boston, 1899.

Rivolta, Il Medico veterinario, 1869.

Rivolta u. Silvestrini, Giornale di anatomia, fisiologia e patologia, 1873, p. 42.

Rivolta u. Delprato, L'ornitoiatria, Pisa, 1880, p. 271.

Rivolta, Dei parasit, veget., Torino, 1873.

Siedamgrotzky, Bericht ueber das Vet. Wesen im Koenigreiche Sachsen, 1872. S. 87.

Stevenson, Journal of Comp. Med. 1898, July.

Theobald, The parasitic diseases of Poultry, London, 1897.

Trasbot, Annales de med. veterinaire, 1879, p. 465.

Trinchera, Clinica veterin, 1899.

Whitfield, The Indian game fowl, London, 1892.

Williams u. Cameron, The Journal of Pathology and Bacteriology, Edinburgh and London, 1896, 3, p. 344.

Wright, The practical Poultry Keeper, London, Paris, Melbourne 1897.

Zuern, Die Krankheiten des Hausgefluegels, Leipzig, 1882, p. 104.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 133.

# The Present Condition of

# San Jose Scale

# in Ontario.

BY

Wm. Lochhead, B. A., M. S., Professor of Biology.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE,
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# Ontario Agricultural College and Experimental Farm

# THE PRESENT CONDITION OF THE SAN JOSE SCALE IN ONTARIO.

By Wm. Lochhead, B.A., M.S., Professor of Biology and Geology.

It is now nearly ten years since the San Jose scale made its appearance in the United States east of the Rockies, and it is about seven years since it first appeared in Ontario. It has made progress in that time in spite of all the efforts which have been put forth to keep it under control. In the St. Catharines district there are but few orchards which have escaped invasion, and many have succumbed to the terrible attack. In the West the scale is very prevalent in South Essex and Kent. Although the scale is so widespread in these districts, yet we must remember that if it had not been for the energetic action of the Government in appointing inspectors, and in passing the Fumigation Act for the treatment of nursery stock, in my judgment, the scale would have spread to most parts of the Province.

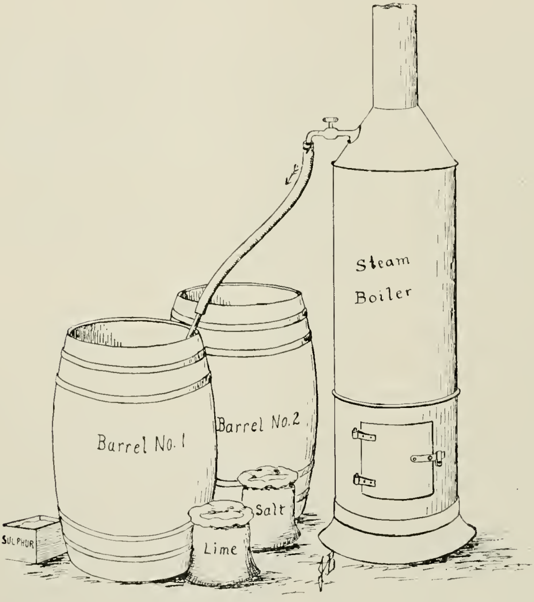
Never before has the San Jose scale problem seemed so easy of solution as it does to-day. After long experimentation we now know that we have methods which are both effective and easy to apply. The whole solution of the difficulty lies now with the fruit grower himself. There are five more or less effective remedies—first, the lime, sulphur, and salt mixture ; second, crude petroleum; third, crude petroleum and whale-oil soap emulsion; fourth, whale-oil soap solution; fifth, the McBain Carbolic Wash. With regard to the lime, sulphur, and salt mixture, its effectiveness was demonstrated beyond doubt by Mr. G. E. Fisher, and it is being extensively used, in the West particularly, as an effective remedy. The chief points of excellence of this mixture are: First, its cheapness ; second, its effectiveness ; third, its cleansing effect upon the tree from both insect and fungous pests. The fact that it is somewhat difficult to prepare and hard on the men and apparatus, has made this mixture unpopular with some of our fruit growers. Where the fruit grower has the proper appliances for making the mixture its operation is not so difficult as it appears.

The crude petroleum is well adapted in the West for apple treatment, and in the Chatham district I fail to hear of the death of a single tree. In that district the oil is easy to procure and the fruit growers are well pleased with the results. The objections which have been urged against crude petroleum are: (1) The great variation in strength of the oil; (2) The disagreeableness of application, and (3) The great liability of its injuring plums and peaches.

The emulsion of crude petroleum and whale-oil soap, although a very effective remedy, has never taken well with the fruit growers, on account of the difficulty which was found in making the emulsion, and of the disagreeableness of the application.

Whale-oil soap solution, although quite effective when properly applied, proved too expensive for the average orchard, and has been given up.

The McBain Carbolic Wash is a new insecticide which has been tried for the first time in Canada this summer and has given good satisfaction wherever it has been tried. Further experiments are necessary, however, to determine if the winter applications of the Carbolic Wash will prove as successful as the summer applications.




W. W. Hilborn's appliance for making the lime-sulphur-salt mixture.

The lime, sulphur, and salt treatment, which the Essex fruit growers are using quite freely, is extremely cheap. Mr. J. D. Wigle, of Kingsville, tells me that it cost him but ten dollars for outside help to spray forty apple trees and eight hundred peach trees with this mixture. Mr. W. W. Hilborn, of Leamington, is also quite enthusiastic over the mixture. He had some hesitation last spring in using it, but when he came to prepare it he found it much simpler than he had expected. He used a boiler, which he procured for ten dollars, to supply the steam for boiling the mixture. He used the 15, 15, 10 formula. The lime he slaked slowly in a coal-oil barrel with four gallons of water; then the sifted sulphur was added with stirring to the hot mixture, and the whole boiled for an hour; then the salt was added and the mixture boiled for half an hour longer. Mr. Hilborn kept a second barrel of hot water always convenient. This mixture was very effective, and I failed to find a single scale at the time of my visit, August 27th. It was applied also against the Scurfy Bark Louse and the Oyster Shell Bark Louse, and the results were extremely satisfactory. The Township of Gosfield, in which Kingsville is situated, passed a by-law last spring compelling treatment of infested orchards, and a township sprayer, Mr. H. Bruner, was appointed to do the work whenever the owner himself cared not to spray. The results were quite satisfactory to most of the fruit growers, and they now see the solution of this problem of the San Jose scale.

In the St. Catharines district, however, the lime, sulphur, and salt treatment has not become popular, but no one seems to doubt its effectiveness against the scale.

PLATE 1. The Kottmeier orchard of about 400 plum-trees at St. Catharines treated with the McBain Carbolic Wash. (Pho. Aug. 14, 1903).

Mr. G. A. McBain has had a very interesting experiment under way, testing the effectiveness of his "Carbolic Wash" (Plate 1.). He undertook to clean up the Henry Kottmeier orchard, which contains about four hundred trees, mostly plums of five years' growth. Mr. McBain has given the orchard three applications. The first was made with his winter wash on the 28th and 29th of April, the second with his summer wash on the 14th and 15th of

PLATE 2. A peach orchard near St. Catharines practically destroyed by the San José Scale, containing 10,000 trees, now neglected and left untreated. (Photo. Aug. 14, 1903.)

July, and the third with the summer wash on the 14th and 15th of August. The winter application, although fairly satisfactory, did not kill all the scale, but as large a percentage as one could naturally expect from the encrusted condition of the trees. Besides, Mr. McBain tells me that he could now guarantee a much larger percentage of scale killed, because he was afraid to use a stronger formula than the one he had been using in California. I examined the orchard on the 14th of August, before the third application, and found but few scale on the trees. The trees looked healthy and had made a decided growth. Some of the leaves of the trees had been singed by the summer mixture, but I think no appreciable damage would be done.

There are two preparations mads by Mr. McBain under the name of Carbolic Wash—the Winter and the Summer preparations. The Winter Wash was used in the first spraying operations and against the aphis. The Summer Wash is, in my judgment, the more effective scale remedy. It is not so black and does not contain so much crude carbolic acid as the winter wash. It remains to be seen how effective the Summer wash will be when applied in the winter, as Mr. McBain intends doing in future.

The McBain Carbolic Wash has been in use for some years in California as a scale remedy. It is a black, oily liquid, and smells strongly of crude carbolic acid. Other ingredients are pine tar and fish oil. The strong point in favor of this wash is the readiness and ease with which the spraying liquid can be prepared. When a barrel of liquid is to be made up, two or three gallons of the black carbolic wash are placed in the barrel and cold water added. The wash dissolves very readily, and the barrel of liquid has a milky appearance. Another feature of the preparation is that its application by the spray pump is not an unpleasant operation. The operator does not need a special suit of old clothes, as he would if he were spraying crude petroleum, whale-oil soap, or the lime, sulphur and salt mixture.

In my judgment the points of the McBain Carbolic Wash which I have indicated are very important ones in future operations against the San Jose Scale, for experience proves that the ordinary fruit grower is influenced mightily by the character of the spraying operation. I believe that the main reason why the crude petroleum, and the other preparations which are effective against the scale, did not take with the people was this very factor—the disagreeable nature of the spraying. As we all know, a perfect insecticide must possess the following qualities:—

1. It must be effective against the insect; 2. It must not harm the plant; 3. It must be readily and easily applied ; 4. It must be cheap.

From my observations this McBain Carbolic Wash possesses at least three of these qualities, and it may have the fourth also, for I do not know what the retail price of it will be. This is an important point, but if the manufacture of the substance is to be made a business matter, then I have not much fear on this point.

In addition there is ground for the belief that this wash is valuable not only for controlling the aphis of apple, plum and cherry, but also as a fungicide for peach-leaf curl, apple scab, and the brown rot of plum, when used at the rate of 1 to 30.

PLATE 3. A large apple orchard near Kingsville very badly encrusted with San José Scale. The owner refused to treat the orchard himself, or to allow the township sprayer to do it for him. This orchard is now a menace to the neighboring ones. (Photo. Aug. 27, 1903.)

PLATE 4. An apple orchard belonging to John D. Wigle, Kingsville, sprayed with lime, sulphur and salt in early spring. Very few scales could be found at time of visit. (Aug. 27, 1903.)

Now as to the future of the San Jose Scale. I do not advocate that the Provincial Government should continue to lay out large sums of money every year in fighting the scale. They might with just as good reason be asked to spend money in fighting the Potato Beetle, the Codling Moth, or the Hessian Fly. The Government, I maintain, has done its duty with regard to the scale; and now that reliable, efficient remedies are known, the matter of controlling the pest must remain with the fruit growers. I am sure that the Government is willing to assist the fruit growers with advice and even with help when necessary.

This help should come in the form of reduction of cost of chemicals, as has been given in previous years, and in establishing a system of Township Sprayers under Governmental supervision, perhaps. To my mind the greatest need at the present time is not a new remedy, for we have efficient ones already, but an organized system of sprayers by whom every orchard can be sprayed at a reasonable cost at the proper time, and in the proper manner Many of our smaller fruit growers have neither the outfit for doing good work, nor the time and help to spray at the proper season. They would be perfectly willing, however, to pay for the spraying of the orchards by a reliable party. In Gosfield Township, Essex County, a township sprayer was appointed last spring, and so far as I could learn from inquiries in the vicinity, the fruit growers are thoroughly satisfied with the results. A prominent grower told me that he no longer feared the scale, so long as he could get his orchard sprayed with the lime, sulphur and salt mixture, and by reliable sprayers at a reasonable cost. (See Plate 4.) A St. Catharines fruit grower thinks the McBain Carbolic Wash solves the difficulty in regard to keeping the scale in check. He thinks that there will now be no difficulty in finding good sprayers to do the work, since the wash is not disagreeable to use. He said that his own men looked upon the spraying operations with crude oil, or the whale-oil soap as a veritable ordeal.

There is another matter in regard to the scale which should be attended to as soon as possible. In the scale-infested sections there are orchards which are never sprayed. As a result they are neglected, and they form veritable breeding grounds for the scale, and other pests. I know of several orchards which are thus neglected. (Plates 2 and 3.). It is not fair to the other fruit growers that they should be exposed to such conditions.

The townships should see to it, and pass a by-law compelling the spraying of the neglected orchards, or to have them cut down and burned. The Government might very reasonably look after the inspection necessary for the proper carrying out of the by-law. We all know how such a by-law would soon become a dead letter through difficulty in getting the local authorities to carry out its provisions. An outsider can carry on the work, but a local man cannot.

Furthermore, fruit growers must recognize the necessity for at least one spraying every year. In badly infested orchards two sprayings should be made.

Finally, good spraying outfits,—a 5-ply hose—not an ordinary garden hose, should be used.

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ONTARIO AGRICULTURAL COLLEGE
Macdonald Institute

**BULLETIN 134**

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Hints on Making

# Nature Collections

## In Public and High Schools

BY

W. H. Muldrew, B.A., D. Paed.
Dean of Macdonald Institute

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Ontario Agricultural College and Experimental Farm
MACDONALD INSTITUTE

# Hints on Making Nature Collections in Public and High Schools

By W. H. MULDREW, B.A., D. Paed, Dean of the Macdonald Institute

## INTRODUCTORY.

A short time ago the Macdonald Institute issued its first leaflet to teachers on the subject of Nature Study. The replies already received show that such assistance as was there proposed is a very real need of the schools, and will be appreciated by the teachers.

The present bulletin treats one aspect of the subject with some detail and is intended to be kept in the schools for permanent reference. It may seem to emphasize the rural and agricultural sides of the question, but this is inevitable from the nature of the subject. The surrounding conditions of country life favor Nature Study for the same reasons that cause Manual Training and Domestic Science to be welcomed in the cities. This does not mean that Nature Study is to be ignored in the urban schools, but rather that its development there will follow somewhat different lines. Other phases will be dealt with in later numbers.

As a centre of interest for the Nature Studies of a school, there is nothing more helpful than a collection of suggestive things from the outdoor world. The value is, however, in the *making* and the *using* rather than in the *keeping*, and this bulletin is intended as a guide to teachers and pupils in beginning such work. We need hardly say that collections, like books and other tools, are but the means, while the end is to be found in the interest that is aroused and the thought that is stimulated.

It is not to be expected that all of these suggestions will be practicable in our schools at once. Teachers have many duties to take up their time and attention, and Nature Study must be content with small beginnings, until it can shew itself worthy of a place with the older subjects of the school-room. The important thing is to make a beginning, however small, and then to grow with the work as results may warrant.

In recent years, local Fairs have given prizes to schools for nature collections, and in some places excellent sets have been shown. The weakest point with these has been want of method and uniformity in the preparation of exhibits which should follow some general system, It is very probable that such competitions will be encouraged more and more in future years in connection with the larger Exhibitions as well as at the smaller Fairs, and it is therefore important that there should be some general standard for the guidance of teachers and scholars.

In the preparation of these instructions assistance has been received from the staff of the Agricultural College. Prof. Lochhead has contributed many practical suggestions besides preparing the sections dealing with insects and aquaria. Most of the illustrations have been prepared for this bulletin by Mr. John Buchanan, B.S.A , of the Experimental Department. Thanks are also due to Mr. F. W. Hodson of the Dominion Department of Agriculture for suggestions gained from his pioneer experiences in introducing school children's exhibits in Nature Study at local Fairs.

This suggestion as to exhibits at local fairs has the hearty sympathy of Mr. H. B. Cowan, Superintendent of Agricultural Societies for Ontario, who is making them one of the important features of exhibitions and fall fairs. Mr. Cowan is now preparing an illustrated pamphlet dealing with this subject.

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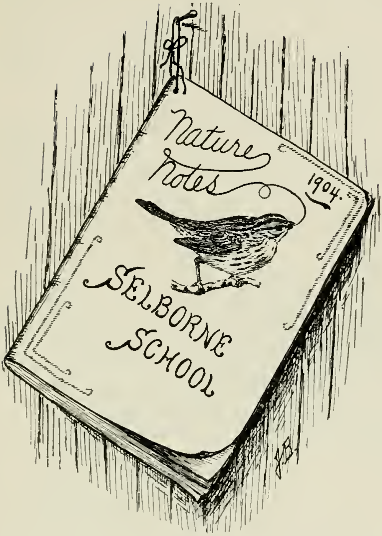
## Collecting Ideas from Nature.




Outdoor nature is full of interesting things and events. Little eyes and ears are quick to see and hear, and little minds are quick to think. Suppose we help them to keep a record of the happenings of this outside world. A simple note-book and a pencil supply the needed outfit; five minutes in morning or afternoon supplies the time; the children will gladly supply the ideas. A brief discussion, a few suggestive questions, and a permanent record will form a worthy lesson to begin the day's work and will not lose its effect. Is there a teacher who cannot do as much? Give date, place and name of observer with all needed particulars. Let older pupils make their own entries, but give equal credit to the earliest efforts. Use only the right hand pages reserving the opposite for later notes and explanations.

What things may find a place in these Nature Notes? All things of interest to children or to the community, in the world of Nature. We suggest a few classes of items from the endless variety supplied by the changing seasons. The aim will be to form the habit of observation rather than to collect information, but the facts will have a value and interest of their own.

(*a*) First things of the season: the return of the common birds, as Robins, Crows, and Bobolinks; the northern or southern flight of Geese, Ducks, and

Fig. 1. Taking Notes.

Gulls; the appearance of hibernating animals as the Woodchuck, Chipmunk, Snake, and Bat; the awakening of the Frogs; the leafing and flowering of the Trees, the opening of the wild Flowers; the re-appearance of Insects as Butterflies, Mosquitoes, Potato Bugs; the coloring and falling of leaves in Autumn.

(*b*) Events of interest: frost, snow, rain, hail, rainbows, new and full moon, eclipses; the beginning and end of sleighing; plowing, sowing and planting, haying, harvesting, potato-digging; making maple sugar; going fishing or berry picking; the birds building nests or feeding their young; crows pulling corn or eating grasshoppers; the young of wild or domestic animals; the swarming of bees; use or harm of birds and insects; tracks of animals in winter.

(*c*) Histories of growth, with descriptions and drawings showing changes from day to day; notes on the condition of some chosen development, as, for example,

(1) A plant from a seed.

(2) A tree, from bud to leaf and flower and fruit.

(3) A bird's or wasps' nest.

(4) A field of grain or roots.

Records of things like these would form a very interesting book. The inspector would be glad to see it. Next year it would be doubly valuable for comparison. A careful summary would be welcomed by any good local paper. It would add much to an exhibit at the autumn fair, for it would shew thinking as well as collecting, and the very best one in the Province would make an excellent bulletin for the schools in 1905.

## Living Collections.

It is not necessary that specimens should be dead and dried, for living things are always of greater interest. Neither is it necessary to keep birds or animals or frogs or fishes in the school-room, though even this has been done with profit, and an aquarium for the development of tadpoles, small fishes, insects, etc., is quite practicable in some places. Potted plants are already common in the windows of well kept school-rooms.

But trees and shrubs are easily planted and form a permanent living collection of constantly increasing value. They attract the birds and other forms of life and shelter the wild flowers. In this way they prepare for wider Nature Study, and, therefore, deserve first attention. Arbor Day need not be limited to one day, but should rather keep pace with a growing interest in trees and plants. No school can afford to neglect the planting of trees and shrubs to beautify its grounds and interest its scholars.

In transplanting from the bush or from a nursery a few simple rules should be kept in mind. The tree joins itself to the soil by fine fibrous roots, and these should be disturbed as little as possible in the uprooting. The roots should also be protected from sun and wind and brought into close, firm contact with the earth in their new home. This is

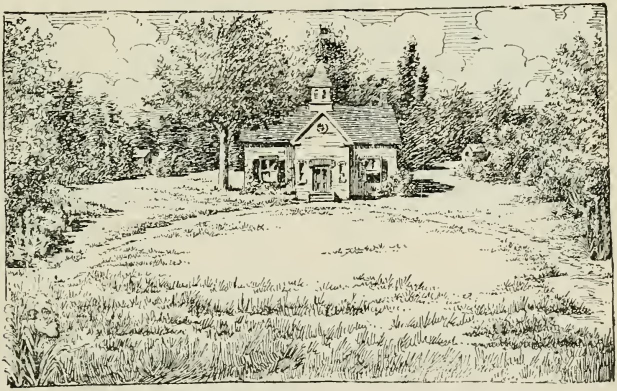


FIG. 2. From Bailey's "Hints on Rural School Grounds."

secured by trampling and pounding good soil (with water added if convenient) around and between the roots, in a hole rather broader and deeper than seems necessary, so that no air spaces can exist. All this is best done in cloudy or rainy weather; but in any case many of the roots will be lost, and the top must be reduced in proportion. There is little danger of over-trimming, for a healthy stem will produce new branches if able to support them.

The Ontario Agricultural College is preparing to grow seedlings of forest trees for the use of farmers who wish to change waste land into woodland. It is very probable that such nursery seedlings will be offered to schools that have shown an interest in such matters, and that will be willing to protect them and study their growth. School grounds may thus become object lessons in forestry for the farms of the neighborhood.

School gardens are now attracting much attention as an aid to Nature Study, and they are encouraged by a special grant from the Department of Education. Such means improve the children as well as the grounds, and have a permanent influence over the whole neighborhood.


FIG. 3. Insect life in winter.

At a recent meeting of the Canadian Forestry Association in Toronto a gentleman described such a garden made in the grounds of the school where he taught twenty-five years ago. It had trees and shrubs from the neighboring woods and flowers grown from seeds, all planted and cared for by the teacher and pupils. The trees are now a foot or more in diameter, and farmers' wives in that section still grow flowers descended from the little school garden. That teacher is now a member of Parliament for the same constituency, and deserves his promotion as well as the familiar bouquets still brought him by his old pupils. Was it worth while to take a little trouble with that little school in the days when Nature Study had not yet received a name?

Our illustration shows a collection of living things with no signs of life. These are cocoons of moths and butterflies gathered during the winter and waiting to be awakened from their sleep of transformation. In the autumn they were caterpillars; the warmth of spring, or of the school-room, will bring them out as beautiful winged creatures.

An aquarium may be arranged for the study of water insects and animals. Failure to keep a healthy and sightly aquarium often attends the efforts of a beginner through neglect of proper care and management. The secret is to imitate Nature, i. e., to make conditions similar to those of some pond where water life flourishes, and to get a good balance of water plants and water animals. When this balance is established the aquarium requires but little attention beyond the addition of water. Large battery jars and preserve jars serve admirably for this purpose.

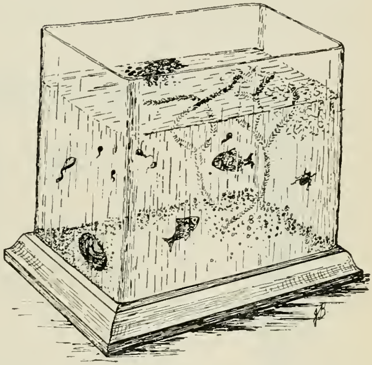


FIG. 4. A very small pond and its people.'

The following common water plants and animals are suited for aquaria: Duckweed, water-milfoil, stone wort, waterweed, snails, water-scavengers, beetles, water-boatmen, back-swimmers, mosquito wrigglers, caddice-worms, etc.

## Collections of Pressed Plants and Leaves.

A flower that has withered and dried in the usual way is useless; it has lost even the likeness of its growing self, and has become brittle, faded and crumpled. But if dried instead between sheets of porous paper under heavy pressure it retains much of its original color and strength in a form that is very convenient for examining as well as for preserving and exhibiting. When thus prepared and mounted on a suitable card with a proper label it forms a useful permanent specimen for study or comparison.

To prepare plants properly in this way, the following materials will be needed: Drying paper (carpet-felt or coarse porous paper), sheets of tea-paper (or smooth newspaper leaves), two pieces of smooth board 12 inches x 20 inches; a few weights (suitable stones of about 10 lbs. each will answer); mounting paper, in sheets 11 inches x 16 inches or 8 inches x 11 inches; liquid glue or strips of gummed paper; labels showing botanical and common name, date, place and collector; a collecting box or vasculum and a note book.

The entire plant, as far as possible, should be in the collection. When this is impossible, as with trees and shrubs, branches with leaves, or leaves and flowers, should be collected and preserved. In drying

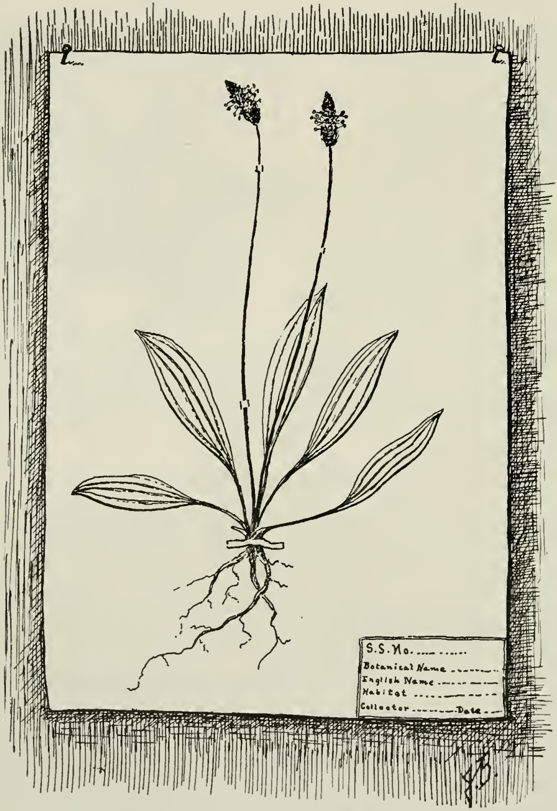



Fig. 5. _A specimen properly mounted. What weed is this?

plants, care should be taken to secure the specimen (free from outside moisture) without breaking any portion of it. It should be spread very carefully between two leaves of tea-paper with sheets of drying paper above and below. Many plants may be placed one above the other, separated by drying paper, and pressed at the same time by weights on the upper board. When a plant is placed thus to be dried, a note should be put with it, stating its name, the date of collection, the locality where it was collected and the collector; for one must not trust too much to memory in these matters. The collection will very likely grow rapidly and experience will soon show the need for keeping notes of every plant collected. Carpet-felt makes excellent drying paper, and can be obtained at most dry goods stores for about four cents a square yard. Instead of tea-paper, ordinary newspaper, cut up into convenient sizes, may be used. The secret of drying plants well is to change the dryers frequently. The more water the plant contains the more frequently should the dryers be changed, and in some cases this might be done daily.

When the specimen is thoroughly dried it should be mounted on a sheet of stiff white paper or cardboard, about 11 inches x 16 inches. For smaller plants, one half this size, 8 inches x 11 inches, will answer very well.

Suitable mounting paper may be obtained from Mr. F. W. Hodson, Dominion Live Stock Commissioner, Ottawa, at a rate of 50 cents per hundred sheets of the larger size. Mr. Hodson will also supply schools with suitable printed labels free of charge. The latter must be carefully filled out and gummed to one corner of the card, while the plant is securely fastened in position by glue or strips of thin gummed paper.

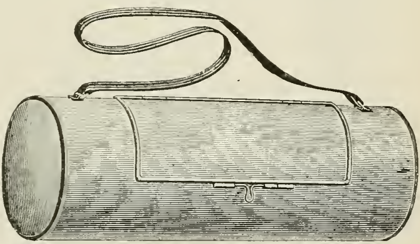


Fig. 6. A Collecting Box.

A close tin box or vasculum about 18 inches long and of a shape suitable for carrying by a shoulder strap, is very useful for collecting fresh plants, and may be easily made by any tinsmith.

## Collections of Grains and Grasses.

Specimens of mature grains, grasses or clovers may be easily prepared and form an interesting exhibit. These should show the complete plant, root, stem, leaves and heads, (or merely the heads with a few inches of stem) with the name of kind and variety in every case. Such

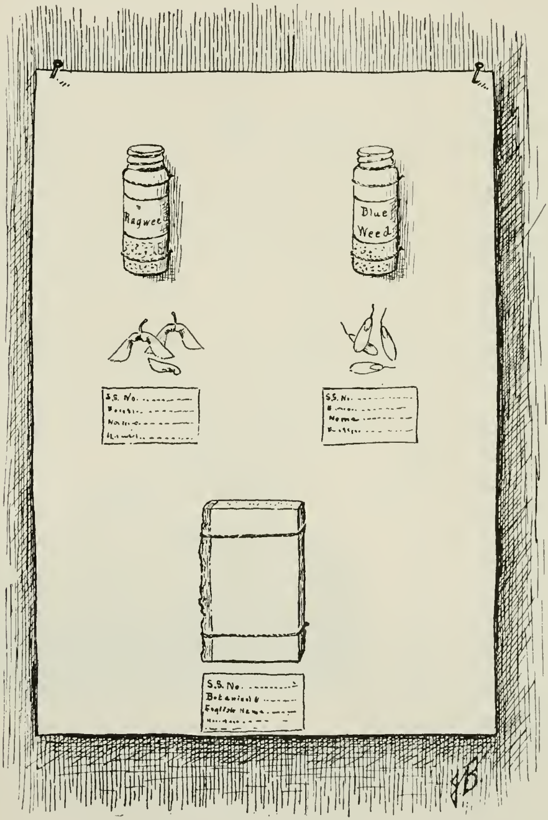



FIG. 7. What are the Tree Fruits?

plants may be pressed and mounted on the usual card by carefully bending the stalk when too long or they may be kept straight and tied in bunches, supported, if necessary, by a light rod or lath.

## Collections of Seeds and Dry Fruits.

It is worth while to learn to know the seeds of noxious weeds that are often mixed with the seed of grain, grass, or clover. These should be collected and kept in suitable small bottles with proper labels. The best vials for this purpose are of clear glass with wide necks and closed by a metal screw-cap. Those holding 1 drachm are of suitable size, being about 2 in. x ½ in and can be secured through local druggists at a cost of 15 to 20 cents per dozen.

These vials are best shewn on sheets of cardboard to which they are secured by loops of cord or elastic. Seeds must be quite ripe and dry to prevent moulding, and the pods or heads should be enclosed as well as the clean seed.

The dry fruits of trees and shrubs are equally interesting and may be fastened in the same way, or by means of glue or mucilage, on similar cards. The keys of the Maples, the acorns with their cups, the winged fruits of Ash, Elm, and Pine all serve for important lessons on the reproduction of trees and the distribution of their seeds. Many Canadians have never seen the seed of the Pine; and many can see no connection between the cones at the summit and the seedlings at the foot of the giant of the forest. A collection of tree seeds carefully mounted and named is an excellent lesson on forestry.

## Specimens of Wood.

Sections of wood from the various kinds of trees form an interesting and useful collection. These should be prepared in such a way as to shew the bark, and two planed surfaces. The size should be 3 inches in length by 1 inch in width, by ½ inch in thickness. Such pieces may be neatly fastened on cards like those used for pressed plants and should be labelled in the same way.

It is better to use sections from the body wood of the trees, but this is often inconvenient and the size given above can be very easily secured from a branch without destroying the tree. Similar sections shewing the work of insect borers or of woodpeckers may be mounted in the same way and will be very useful.

## Collecting and Preserving Insects.

Insects may be collected at all seasons of the year, but the best time is undoubtedly the summer months. Many collectors find the moths and butterflies most interesting on account of the extreme beauty

FIG. 8. The Boy and the Insect.

of their wings; others find greater interest in beetles; still others prefer the study of groups which are not so beautiful to the ordinary observer. Insects of special harm or use, for any reason, are always interesting

The great majority of the moths must be caught at night for they rest during the day time. Most of them are readily attracted to lights, and may be secured by devices such as trap lanterns. Many insects are also attracted readily by sweets, such as sugar or molasses, and if a sweet solution is brushed on the bark of trees, moths frequently gather at such trees after dark and are easily captured.

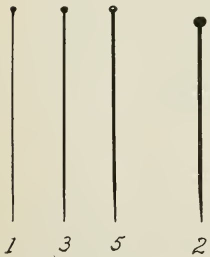




FIG. 10. 1, 3, 5, Insect Pins. 2. German Steel Pin.

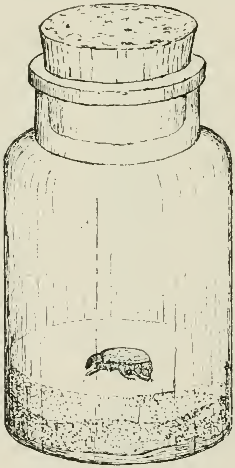


FIG. 9. The Poison Bottle.

The following articles are needful for collecting: Cyanide bottles, one or more; insect pins; cigar boxes or insect cases; spreading boards, different sizes; date and locality labels; larvae bottles

The cyanide bottle is needed for killing insects before they can be pinned. (Fig. 9.) This bottle may be made as follows by any druggist: Place two or three lumps of cyanide of potassium, of the size of beans, in a wide mouthed bottle, pour in sufficient water to cover the lumps, and add enough plaster of paris to take up the water. If the bottle is left uncorked for a short time, the plaster will rapidly set and harden. Care should be taken not to inhale the poisonous fumes which come from this bottle, nor to leave the cork out for any length of time, for the cyanide would soon be lost through the escape of the fumes. It is often desirable to place a circle of thick blotting paper on the surface of the plaster to absorb any moisture which may form.

Insect pins do not readily rust when placed through the bodies of insects. Probably the best are made of German Silver. They may be be obtained in assorted sizes from Alex. Stewart, Druggist, of Guelph, at a cost of 25c. per package of 150, post paid. The most desirable pins for the ordinary work of the collector of insects are Nos. 1, 3, 5,—No. 1 being suitable for small insects, No. 3 for insects of medium size and

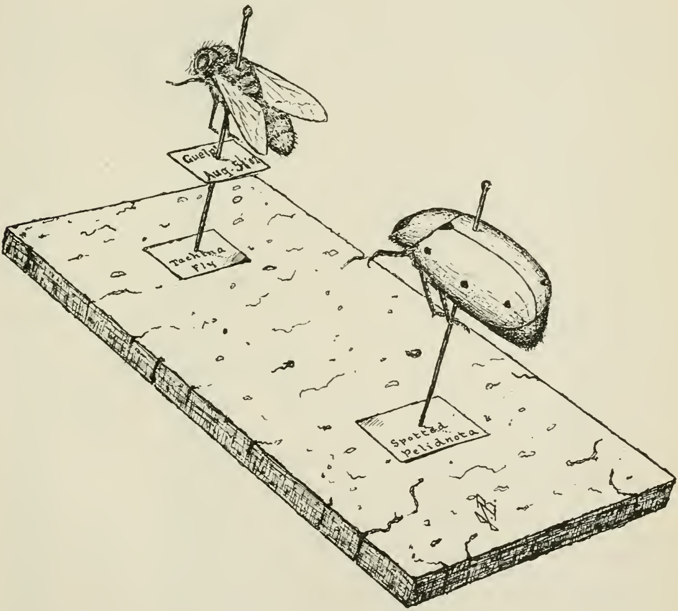



FIG. 11. Method of Pinning.

No. 5 for insects with large bodies. German steel mourning pins with glass heads are second best, and may be had at any dry goods store. Care should be taken when pinning insects to thrust the pin through two-thirds the length so that from one-third to one-quarter of the pin projects above the back of the insect. The beetles should be pinned through the right wing cover; other insects through the thorax, or that part of the body just back of the head. (See Fig. 11.)

A handy boy can readily make an insect net for himself. All that he requires is a broom handle, three feet of stout wire, a little heavy sheeting, and one yard of cheese cloth. The wire can be bent into a circle of about ten inches in diameter and the ends fastened firmly into the end of the broom handle. The cheese cloth is made into a bag and attached to the band of sheeting which folds over the wire. (Fig. 12.)

The collector will be a little awkward at first in the use of the insect net, but with practice the wiliest and most rapid of insects may be captured. Care is needed in transferring the insects from the net to the cyanide bottles lest the wings and legs should be injured.

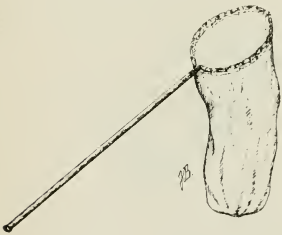


Fig. 12. The Insect Net.

Fig. 13. The Insect and the Boy.

Moths and butterflies when captured seldom die with their wings outspread so it is necessary to use spreading boards for those forms which we desire to preserve in this position. (Fig. 14) shows the construction and use of a spreading board. Two pieces of pine, fastened together by cleats at the end, are left wide enough apart to admit the body of the insect. Narrow strips of cork are then tacked on the under side of the pine strips so as to form a bottom to the groove and to serve as a support for the pin upon which the insect is placed. Another broad strip is nailed to the cleats and forms the base of the spreading-board. Of course the insects must be pinned to the spreading-board before they have time to become brittle, and while they are in a relaxed condition. It will require some patience and skill to spread the wings of the smaller moths without injuring them, but practice will make perfect.

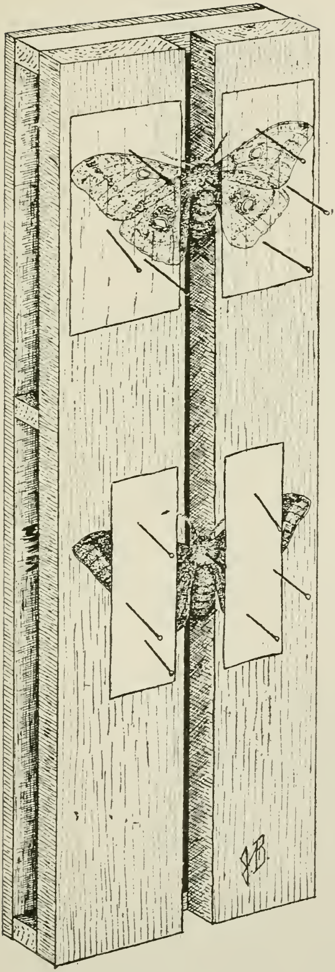


FIG. 14. The Spreading-board.

Cases are necessary for holding and displaying the insects captured. At first the collector may use cigar boxes very satisfactorily, but the time will come when he will not be satisfied with anything less than good insect cases, which will keep out dust and minute insect pests. The bottoms should be lined with sheet cork which can be purchased from dealers in insect supplies, or with bottle wrappers obtained from druggists. For exhibition purposes insect cases should have glass covers, if possible. Collectors who wish to make their collections look tidy, neat and artistic may line their cases with fine, glossy white paper. This improves very much the appearance of the collection as a whole.

Every specimen which has been placed in a collection should have a date and locality label and a name label attached. These labels may be written free hand or they may be printed with pen and ink. Printed labels, as a rule, look much better than written ones. The proper time to place date and locality label upon the insect is at the time of pinning, and it is usually placed below the insect about a third of the way up the pin. The name label is placed near the bottom of the pin.

With regard to the preservation of the larvæ of insects, much may be said. It is important that collectors should preserve the larval forms as well as the other stages of the insect for it should be borne in mind

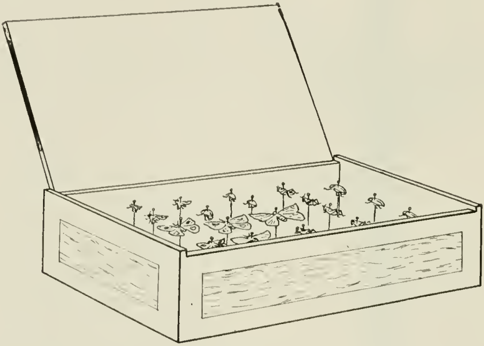


FIG. 15. A Simple Insect Case.

that those collections are of highest value educationally which show the life history of the insect in all stages—the egg, the larva, the pupa and the adult. The larval stage of the insect, moreover, should be carefully

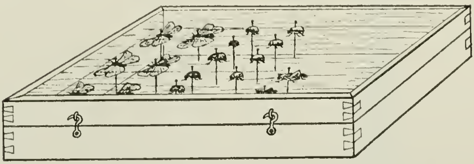


FIG. 16. A good case with glass cover. Specimens not labelled.

preserved throughout all its molts for the mature larva frequently differs considerably from the younger forms. Some collectors place the larvæ in liquid in vials; other prefer to inflate them and have them placed on pins beside the adult forms. For school purposes, however, the vials are to be preferred.

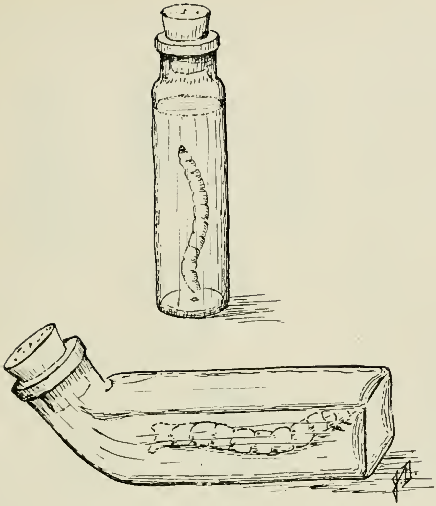


Fig. 17. Vials for preserving larvæ in liquid.

A good preserving liquid may be made as follows: 50 parts methylated alcohol, 50 parts water, 4 parts formalin. This mixture can be prepared by any druggist at a cost of about 25 cents per pint. It must be kept closely corked as it evaporates very readily. Special bottles with bent necks are very suitable but rather expensive, costing about 5 cents each. Two drachm homœopathic vials with wide mouths may be obtained from druggists at much lower rates and will answer very well.

## Historical Collections.

Objects that link the past to the present are of great educational interest and value. Such things are found in every neighborhood, and the school is the proper place for their keeping and interpretation. The boy who has picked up an ancient arrowhead or pipe from the site of some long-forgotten village may well feel a personal interest in the early exploits of Huron and Iroquois. But we need not go back to Indian times for relics of the past. The early pioneers of our own race have disappeared, too, and their primitive weapons, tools, and manufactures are hardly known to the children of to-day.

How much true history would be suggested by a few articles from a settler's outfit of 100 years ago? The flint-lock musket, and the smooth hollowed stone used for grinding grain by hand, are almost as far removed from the present as are the tomahawk and the bow-and-arrow. Those who possess such relics would often be glad to place them where they could be assured of permanent care and usefulness to successive generations of children.

Articles of this class should be carefully numbered and described in a note-book or by means of tickets securely fastened to them

Small objects are best fastened on cards in the same way as specimens of wood described on page 10

Such a collection needs little care or preparation, and if properly used will be both interesting and instructive.

Mr. David Boyle, of the Education Department, Toronto, is our best authority on all that pertains to these relics of our past history, and he is always ready to assist collectors in understanding their "finds." In case of doubt or difficulty he will be glad to hear from teachers and scholars, and will be able to explain most of the objects that come under this heading.

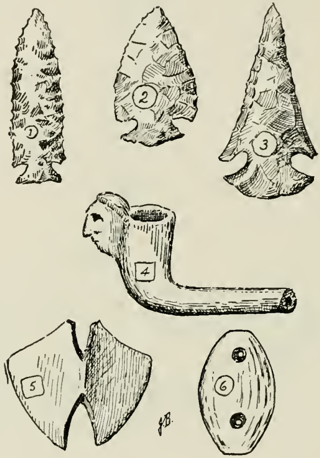



Fig. 18. What are these? Who made them?

The Provincial Museum, of which Mr. Boyle has charge, is one of the best, in Archæology, on this continent, and specimens of more than local interest should be deposited there for public use and safe-keeping. Due credit will be given for all such donations. which will be exhibited over the name of the collector.

Fig. 19. What birds are these? Where is their nest?

## Miscellaneous Notes.

There are many things not mentioned previously that might find a place in a good school collection of natural objects. Such are specimens of the work of animals: Birds, insects, squirrels, etc. The wasps were the first pulp and paper makers just as the beavers were carpenters and architects and the birds weavers and masons. This work is worthy of careful study and can be easily kept in a school-room.

Boys often collect birds' eggs, but this is a destructive practice and should be discouraged in every way in the making of children's collections. A careful description of a nest and its eggs with dates of building, hatching and flying in the "Nature Notes" of the School-Room is far better than the ruined home with its empty shells. It should be known also that the destruction of harmless birds or their eggs is an offence punishable by fine or imprisonment. In this way the law recognizes the value of the birds in destroying insect enemies of farm and orchard, and in entertaining us by their songs.

There is one bird, however, that deserves no such protection. It builds no nest at all but lays its egg along with those of one of its neighbors where it hatches out and bullies the honest nestlings, often causing their death. When such an egg is found in a nest it should be destroyed for the sake of the others. What bird is this?

FIG. 20. One of the earliest spring birds colored "like the sky above and like the earth below." Did you ever find the nest?

In many places very good local collections of rocks and minerals may be made. These should be ticketed or labelled so that their names and localities may be readily seen, and in the case of useful minerals the composition should also be stated in some simple way. For instance, magnetic iron ore might be shown as containing nearly three-fourths of its weight of iron, or crystalline marble as merely a form of limestone.

Stones or pebbles which show the action of natural forces like frost, running water, etc., have an interest and a use without regard to the materials which they contain. Specimens of fossil animals or plants are of great value as illustrating the simple world-history, now taught in connection with physical geography.

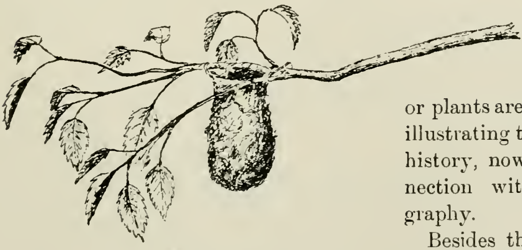


FIG. 21. A good drawing. Do you know this nest and its owner?

Besides the actual objects as here described representations such as pictures, drawings, water-color paintings and photographs from nature are all valuable additions and can be used to beautify the school room as well as to improve the minds of the pupils. Scholars should be encouraged to draw simple natural objects, and the best work should become a part of the school collection. This is one means of cultivating the natural fondness for expression by drawing and coloring which has been too little helped by our schools.

## Books on Nature Subjects.

The Department of Education now grants liberal assistance to school boards in forming libraries for public schools, and many such have been established in recent years. Each of these should contain good books of reference in the various departments of Nature Study. Children should be encouraged to use these in supplementing their observations, but never as text-books or as substitutes for original work. The teacher, too, needs the help of suitable books of reference and cannot do his best work without them. We give here a list of recent Canadian books; similar lists of American publications may be had from booksellers or publishers.

| | |
|---|---|
| Guide to Nature Study, Crawford; Copp Clark Co. - - - | .90 |
| Modern Nature Study, Silcox & Stevenson; Morang & Co. - | .75 |
| Public School Nature Study, Crawford; Scott, Dearness and Elliot; Copp Clark Co. - - - - - | .40 |
| Agriculture, James; Morang & Co. - - - - | .30 |
| High School Botany, Pt. 2, Spotton; Gage & Co. - - - | .60 |
| Sylvan Ontario, a guide to our trees and shrubs, Muldrew; Briggs. | .75 |
| Birds of Ontario, McIlwraith; Briggs - - - | 2.00 |

The following publications may be had free by teachers upon request to the Department of Agriculture, Toronto:—

Reports of Entomological Society.
Birds of Ontario in relation to Agriculture, - - Nash.
Nature Study, or Stories in Agriculture - The Staff of the O. A. C.
The Weeds of Ontario, - - - Harrison and Lochhead.
Insects and Plant Diseases. - - - Panton and Lochhead.
The Teaching of Agriculture in our Public Schools, - James.
The Grasses of Ontario, - - - - Day and Harrison.

# THE OPINIONS AND EXPERIENCES OF TEACHERS AND INSPECTORS.

## Extracts from Letters received in answer to the first Macdonald Leaflet on Nature Study.

*"Within a short distance of our School, we found stratified rocks showing marble and limestone; a perfect miniature glacier; a canyon forming the gorge of a little Niagara; rocks in all stages from blocks 6 ft. by 8ft. on the hillside, to the finest sediment on the plain below; roots petrified by the action of lime in the soil. Thus we saw in our own little world the action of the same forces as are seen in the Alps, in Colorado, in the Nile and Ganges, or in the fossils of past ages." (Condensed).*

*"Every Friday afternoon he devoted to this study, but it did not meet with the approval of the parents or Trustees. The objection was that 'He was filling the children's heads with nothing but nonsense about weeds when they should be learning Arithmetic and Writing,' and so of course Mr. Blank got his discharge."*

*"What is the attitude of the teachers? Never hear them mention it except when we appear at a Convention, and we hear a lecture on it and it is good, then we say so and forget all about it."*

*"What are the most serious hindrances? Downright neglect of the teachers, also no definite work to do on the subject. It betters discipline by making the teacher and pupil more conversant."*

*"The teachers are willing, but they do not know how to set about the work intelligently. They are so willing, and the clamor for some such work has been so incessant that they are ready to follow any method that offers. I do not think that the word 'clamor' is too strong. I have talked to many intelligent people in rural districts, and while there is no demand for such a thing as Nature Study (because they do not know it by this name), there is a strong feeling that much of the time of the child could be put to more profitable use, and that education should be of more practical service."*

*"I have heard the question asked repeatedly, How are we to teach a subject about which we know less than the pupils? How can we act as guides where we know nothing?"*

*"In the schools I have, for over half a century, endeavored to inweave the methods of Nature with the ordinary methods. In the Press and on the Platform, I have strenuously urged a revolt against the old Parrotism which made Memory a lumber garret and Heart and Intellect rooms to let; and a loyal return to the long outraged Queen, a submissive*

*study of her will, her ways, her beauties and her mysteries. Years have but increased my contempt for the Rote system of Cram, (not teaching), a system which 'put the cart before the horse'; a system which taught Names before Things, feeding the child on symbols without realities, and leaving him at last stunted, nauseated, paralyzed. He might pass Examinations as these things go, but those who never 'passed' passed him in the race of life."*

*"How am I to educate 135 teachers in Nature Study? Shall I hold a Summer School, or what is to be done?"*

*"I have taught all grades of Public and High School Work, and am a Specialist in Science, yet I must confess to you that I am unable to meet the demands of this new line of work."*

*"We cannot too soon do away with the dry, uninteresting second and third readers. We want lessons on the animals, birds and plants of our own country and not those lessons on things which are never seen except at a circus."*

*"Your letter comes like a ray of sunshine to me, for as yet I see no possibility of being able to take a special course in Nature Study, and I know that I have wasted much valuable time and lost many golden opportunities in not being able to take up the work properly. I know so little that when I try to follow a plan I am lost, and hitherto I knew not where to apply for information and assistance."*

*"I have heard excellent teachers of long experience threaten to resign their positions if called upon to teach all that is required by this new draft of proposed regulations."*

*"Instead of quarreling on the way to and from school, they have their eyes and ears open to find new plants, birds or animals. The gloomy days and dull Friday afternoons are brightened up by Nature Study talks."*

*"The chief hindrance I have found is the want of time. Too much importance is put on promotion examination in this county to put much time on Nature Study."*

*"The Government could help a great deal in Nature Study by giving to each school a book, containing pictures and simple descriptions of the common birds, animals, and plants of Ontario."*

*"The children can name and tell some thing about nearly all the birds in this neigborhood. I know them only as they tell me, and they often bring me new plants and ask me about them. Very frequently, I do not know and cannot find what they are, and thus lose excellen opportunities."*

*"The size of our grounds would not permit a school garden, but all the school children in the city were given seeds to take home and care for, and at the end of June we are to have a flower show in the rink. Each child is to bring his best plant for exhibition."*

*"The practical work in this study began in the school as the result of prizes offered by the Local Fair for School Children's collections of Natural objects. The Inspector was in thorough sympathy with the work of introducing this study into the schools and made a special visit to his schools with a lecturer on Nature to encourage them to undertake the study and collection of one class at least, of natural objects"*

*"We made a beautiful collection of colored autumn leaves which I waxed and the children mounted on our heavy mounting paper."*

*"There were no ill effects on the other studies or discipline. On the other hand it seemed to be almost a recreation from the heavier studies where its facts were often made use of, and tended certainly to a closer relationship between the teacher and pupil."*

*"My pupils were very much interested in the work and saw a great many things during their walks to and from school that they had not taken any notice of before we began our collection. The weeds we were not able to classify we sent to the Experimental Farm and thus found their names. I enjoyed the work thoroughly and my pupils did also. We had very few books except some Bulletins from the Agricultural College."*

*"About four years ago we started keeping a record of the first appearance of different kinds of spring birds, date of appearance, observer, and remarks. We have kept these records from year to year. Pupils have learned to see the birds and know and love them, to study their uses and relations to the rest of Nature. Some of our most destructive boys have become the birds' best friends. We have brought the flowers and ferns of the woods into the school and planted them in our window-gardens. Marsh-marigolds, hepatica, violets stored away in the fall, we have blooming in the windows before the snow is off the ground."*

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## NOTICE.

During July of the present year a Summer School in Nature Study for Teachers will be held at the Macdonald Institute. The work will be suitable for public schools, and the fee will be nominal. Full particulars may be had upon application to the Dean.

ONTARIO AGRICULTURAL COLLEGE

**Bulletin 135**

# The Cream-Gathering Creamery

BY

H. H. DEAN, B.S.A., Professor of Dairy Husbandry

AND

J. A. McFEETERS, Instructor in Dairy School, O.A.C.

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# THE CREAM-GATHERING CREAMERY.

By H. H. Dean, B.S.A., Professor of Dairy Husbandry, and J. A. McFeeters, Instructor in Dairy School, O.A.C.

The manufacture of butter on the farms of Ontario is carried on in many cases under discouraging circumstances. Labor is becoming more difficult to secure each year, and especially the kind of labor required to make good butter. Not only is the labor problem a serious one, but the fact that many farms lack suitable utensils and a suitable place in which to set the milk and make butter, causes a very inferior quality to be produced. Then, again, this butter is often "traded out" for dry goods and groceries, where no discrimination in price is made between good and bad butter. This system does not encourage the good buttermaker, but places a premium on carelessness and inferior butter. In a discriminating market the difference in price between inferior dairy butter and the best creamery butter is from five to ten cents per pound. The difference is sufficient to pay the cost of manufacturing at the creamery, and leave a good margin of profit to the farmer. Besides this, the work on the farm is lessened very much by having the butter made in a creamery. If the persons producing "ten-cent butter" were able to produce it so cheaply that they make a profit at this price, the situation would not be so bad. However, when we consider that the average food-cost of one pound of butter is probably about ten cents, the profit on such butter is very small, if, indeed, it is not produced at a loss. Not only does the farmer lose money through inferior dairy buttter, but the merchant, the dealer, and the reputation of Canadian butter, all sustain a loss. The remedy for this in the majority of cases, is the adoption of the creamery or co-operative plan of buttermaking.

## Cream-gathering and Whole Milk Creameries.

Many districts, owing to the small cow population scattered over a considerable extent of territory, are unsuitable for delivering the whole milk at the creamery. The cost of hauling the milk from the farm to the creamery and the skim-milk back to the farm is altogether too great, hence the plan of creaming the milk on the farm, by setting it in cans or pans, or by means of a cream separator, and sending only the cream to the creamery, is being more generally adopted. While the average quality of the butter is not so good under this system, the advantages outweigh the disadvantages in many cases. The cream-gathering creamery is a great improvement over the plan of making butter under the conditions which prevail on the average farm. There are farm dairies which turn out a quality of butter equal to the best creamery, but they are the exception rather than the rule.

## The Cows.

The dairyman satisfied with anything short of the best cows obtainable may not be considered progressive. If the best native or grade cows are used for foundation stock, the herd may be very much improved by raising the heifer calves from these cows, if sired by pure-bred males belonging to one of the dairy breeds. These heifers should be reared on new milk for about three weeks, then be gradually changed to warm, sweet skim-milk. In addition, they should be fed some ground oats and bran mixed in equal parts, green feed in summer, and clover hay and roots in winter. They should be kept in a thrifty, growing condition, but not too fat. They should freshen when about two and one-half years old, and again twelve to fifteen months later. At the end of the second lactation period all heifers which do not give at least 6,000 pounds of milk, or make 250 pounds of butter, should be disposed of, unless in special cases, when a third trial may seem to be advisable.

To find the individual production of the cows, it is necessary to weigh the milk from each cow at stated intervals throughout the year, and also to take samples for testing with the Babcock test, in order to determine the fat in the milk. The pounds of milk given in any period of time multiplied by the percentage of fat in the milk, plus one-sixth, is approximately the butter produced.

For example, if a cow produced 30 pounds of milk daily on three consecutive days in the month of April, the pounds of milk produced for the month would be about 900. If this tested 3.5 per cent. fat., the pounds of milk fat would be 900 x 3.5, divided by 100 equals 31.5 pounds fat ; 31.5 plus 1-6 equals 36.75 pounds of butter for the month. The sums of the individual monthly milk and butter production would be the approximate amount of milk and butter produced by each cow during the year.

## Feeding the Cows.

Where cows have plenty of good grass and are in good condition, no other feed is necessary. Where the pastures are short they should receive green peas and oats, green clover, corn or mangels, or, what is preferable, considering the cost and convenience, a small silo should be filled with good corn for summer feeding. This silo should not have more than three or four square feet of surface for each cow to be fed. About twenty pounds of corn silage and two to four pounds of bran or chopped oats will maintain the milk flow during a period of short pasture.

For winter feeding, a daily ration of corn silage (35 pounds), clover hay (8 to 10 pounds), mangels (20 to 30 pounds), bran (4 pounds), oats (3 pounds). and oil cake (1 to 2 pounds), will produce a satisfactory and economical flow of milk with good cows. If possible, the hay should be cut, the mangels pulped, and both mixed with the corn silage from six to twelve hours before feeding. The meal should be fed according to the milk flow, using about 8 pounds of the mixture for each 30 pounds (3 gallons) of milk produced, or for each pound of butter in the milk. The careful feeder will soon learn the capacity of each cow for economical milk and butter production.

## Care and Management of Cows.

All cows should be treated kindly. This is especially necessary with the young cow. Vicious cows are usually the result of bad handling and harsh treatment. Cows should also be kept in clean stables, which are well ventilated, light, convenient and sanitary. While in the fields, and where possible in the stables, they should have access to plenty of pure water and clean salt.

The cows when inside should be kept clean. This can be done by having the stalls of proper length with a drop behind the cows, and by using the currycomb and brush frequently on the cows. If the hair on the hindquarters and tail is clipped in the fall, it is much easier to prevent dirt sticking to them.

Milking should be done regularly, with clean, dry hands. The milk pails should be clean and of uniform weight for weighing the milk. Immediately after milking the milk should be strained through a fine wire strainer and two to four thicknesses of cheesecloth. The milk should then be set or separated as soon as possible.

## Creaming the Milk.

There are three common methods of getting the cream from milk—shallow pans, deep cans and the modern cream centrifuge or separator.

Shallow Pans. Cream from small, shallow pans is frequently not suitable for sending to the creamery in hot weather, because it is usually sour when removed from the milk or shortly after. If the patron has a clean, cool cellar, free from bad flavors, dust and draughts, where the temperature does not go above 60 degrees at any time, the cream from milk set in small pans may be in fairly good condition. Such cream should be removed from the pans about twenty-four or thirty-six hours after setting, and while the milk is still sweet. The cream should be taken off carefully by first separating the cream from the edge of the pan with a thin-bladed knife. Then wet the edge of the pan with some of the milk, when the cream may be carefully run into a cream can, removing as little of the skim-milk as possible. Perforated skimmers should not be used, as they are wasteful of the fat. The pans, after skimming, should be emptied at once, be rinsed with cold water, then washed with hot water, and afterwards scalded and put out in the air and sunshine. Pressed tin pans without seams, or graniteware, should be used.

Deep Setting. The best method of obtaining cream by gravity is by setting the milk in cans which are about eight inches in diameter and twenty inches deep. These cans of milk may be set in a stream or box of running cold water or in ice water. The temperature of the water should be from forty to forty-five degrees F. A very good rule is to have some ice in the tank all the time. The milk should be put into the cans as soon as possible after milking, then set in the cold water, with the covers on the cans. The water should be as high as the milk in the cans, or the cans may be put under the water, if made for that purpose. At the end of twelve or twenty hours the cream may be taken off by means of a cone-shaped dipper from the top, or the skim-milk may be removed from below the cream through a suitable tap. It is necessary to have a glass in the side of the can near the tap, so that the operator can tell when the skim-milk is all removed. Cans which are skimmed from the bottom should be either cone-shaped or slanting on the bottom, so as to remove any sediment there may be with the first-drawn skim-milk, and also in order to assist in removing all the skim-milk from under the cream. The skim-milk next to the cream line may contain an extra amount of fat, but as a rule it should be drawn quite closely to prevent the cream being too thin.

Some cans are stationary in the creamer box. This plan saves the labor of lifting the cans in and out of the water, but they are more difficult to clean, and more liable to rust and leak when so fixed.

The cans should be treated similarly to the pans when washing them—empty at once, rinse with cold water, then wash with hot water, scald and put outside. Where a double set of cans are available, it will pay to allow the cans to set twenty-four hours, otherwise they must be skimmed and washed twice a day.

The cream should be kept in cold water until it is called for by the driver, which should be daily in hot weather, and not less than three times a week at any time. It is very important that the cream be kept sweet until it is delivered at the creamery. The patrons can assist in this matter by keeping the cream cold. All the cream on hand should be given to the driver. The plan of holding some of the cream back in order to get a higher test is not advisable, as it tends to spoil the quality of the butter, and is of no advantage to the patron, but rather a disadvantage, when the Babcock test is used.

The Cream Separator. For those patrons who have six or more good cows a hand separator is a great help. If some power is available, such as steam, electric or tread, it reduces the labor and expense to have the separator run by power other than hand. However, these machines are now made so that hand power is practicable. There is no best separator. No one machine has all the good points, and no one is free from all defects. There is, also, in many cases, as much difference between machines of the same make as between those from different manufacturers. The best cream separator is the one which can cream the most milk in a given time, leaving not over five-one-hundredths of one per cent. fat in the skimmilk, and giving a cream testing not less than twenty-five per cent. fat, and at the same time can be purchased at a reasonable price, with a guarantee from the manufacturer that it will do the work claimed for it, or the machine is to be removed without cost to the purchaser.

The most convenient place for a separator is in a room connected with the stable. The whole milk is then convenient for separating and the skim-milk for feeding. This room, however, as well as the machine should be kept clean. This involves carrying hot water from the house for cleaning, and frequently this is neglected, and the room and the machine are often found in anything but a cleanly condition.

If extra help or mechanical power are available, the separator may be started soon after milking commences, so that the cream and skim-milk are separated shortly after the milking is done. Where this is not practicable, the separating should take place as soon as possible after milking. The bowl of the separator should be wet and warmed by pouring in a quart or two of hot water before allowing any milk to enter. This prevents the cream sticking to the bowl, and allows of a more complete separation. The speed should be as uniform as possible, at the rate recommended by the manufacturer. A little above this speed, five or six turns to the minute, will do no harm. The supply can should, as far as possible, be maintained nearly full of milk. After all the milk is out of the supply can, a quart of warm water may be added to the bowl to flush out the cream. The bowl should then be allowed to stop of its own accord, then be washed. The slime on the inside of the bowl should be burnt. After washing and scalding, the parts should be exposed to the air in a clean place. The skim-milk tubes and all parts not easily cleaned with a brush should receive special attention at the hands of the person responsible for washing. Sometimes bad flavors and sour cream result from improperly washed machines. It is needless to say that the machine should be thoroughly washed after each time of using. Merely rinsing with cold water and washing once a day or once a week is not sufficient.

Immediately after separating the cream should be set in cold water and stirred until it reaches a temperature of about 50 degrees. Fresh cream should not be added to cream from previous separations until it has been cooled down to below 60 degrees. Warm, fresh cream added to the older cream causes unpleasant fermentations, which give the cream a bad flavor.

## Rich Cream Advisable.

Not more than ten or twelve per cent. of the whole milk should be taken in the form of cream. Where scales are convenient, it would be well for those using the hand separators to weigh the milk and cream occasionally in order to see how much cream is being taken. Where there are no scales, the cream should be measured. From ten gallons of milk not more than one to one and a quarter gallons of cream should be taken. Using too much water or skim-milk to flush out the bowl will cause a thin cream.

The advantages of rich cream are :

1. The patron has more skim-milk for feeding stock.

2. It costs less for hauling the cream to the creamery.

3. Less labor and expense are required in cooling the cream at the farm and factory.

4. Less vat and churn room are needed for a given amount of butter.

5. There is less danger of the cream becoming too sour.

6. There is less loss of fat in the buttermilk by churning rich cream, and the quality of the butter is better because it can be churned at a lower temperature than can poor cream, or cream containing a low percentage of fat. The cream at the farm should not test less than twenty-five per cent. fat from the hand separator.

Wooden stirrers should not be used for stirring cream in the can. These are difficult to keep clean, and often impart a bad flavor to the cream. The stirrer should be made of tin, with few seams, and all crevices should be filled with solder.

The patron's cream can should be rinsed with very little water when it is emptied into the driver's pail, as this dilutes the cream. It is preferable to remove the cream adhering to the sides of the can with some sort of a scraper, but this must be kept clean.

## Delivery of Cream.

The importance of making frequent collections of cream is a matter too often underestimated by creamery managers. The facilities at the command of the average patron for keeping milk or cream in a clean, sweet condition are very limited, and it is very seldom that cream left in the hands of patrons for more than three days will prove to be of fine quality. It is quite safe to say that, other conditions being equal, the more frequent the collections of cream, the better will be the quality of butter produced.

On the other hand, the cost of collecting, which is one of the largest items in the cost of manufacture, has to be considered. The greater the amount of cream obtainable in a given area, the lower will be the cost per pound of butter for collecting.

While seeking to practice economy on one hand, quality of butter should not be lost sight of on the other. It is, or should be, quality which determines the commercial value of dairy products.

A district or route which will not furnish sufficient cream to warrant making at least three collections per week during the summer months will scarcely be profitable.

At times we find some drivers adopting the practice of omitting to call on patrons supplying small amounts of cream, and especially those located at outlying points. The fact should not be lost sight of that the addition of a few small lots of cream that have developed a high acidity or an objectionable flavor, from a pantry or cellar, may materially lower the grade of the butter manufactured from the entire load.

A really choice quality of cream will scarcely be obtained unless there are from four to six collections made each week.

## Means of Delivery.

Oblong or oval tanks have proved very satisfactory for the use of cream collectors. The sides, top and bottom, should be well insulated, and the edges of the lids inlaid with cork in order to make a close joint. The inner lining should be of heavy tin (22 or 24 gauge), with as few seams as possible. Long, oblong tanks require some support for the sides, and should have two square "wings" or partitions, extending from the top to within one or two inches of the bottom. These "wings" prevent, to some extent, the swaying and splashing of the cream from one end of the tank to the other while en route to the creamery. The oval-shaped tanks, however, do not seem to require any special "splash-wings."

In placing an order for new tanks, such specifications of outlets or "taps" should be given as would best serve the requirements of the particular location of the factory. For instance, if the receiving door or window were accessible from one direction only, then it would be necessary to have the outlet of the tank on the side or end next the creamery. A tap or other outlet placed in one corner of a tank affords the best possible means of draining, as the platform or driveway may be levelled so as to throw one rear waggon wheel lower than the rest, thus causing the tank to drain freely.

As a creamery inch contains about 113 cubic inches, the capacity in inches may be estimated by dividing the number of cubic inches by 113. The capacity in pounds may be obtained by dividing the number of cubic inches by 27.5848—the number of cubic inches in one pound of cream.

Insulated or jacketed cans, holding from 30 to 35 creamery inches, are preferable in some ways to tanks. Where these are used a buttermaker is sometimes able to "grade" the cream when receiving it at the factory. If the contents of one can is found to be overripe or "off" in flavor, a maker may locate the source of trouble with much less difficulty than when tanks are used. On the other hand, however, well constructed tanks give better protection to the cream during transit. At creameries where both tanks and cans are in use, the temperature of the cream received from the tanks during warm weather is frequently six degrees lower than that delivered in cans.

The ideal system of delivery would find its nearest approach in the use of separate cans for each patron. The measuring or weighing and sampling would then justly fall to the buttermaker, who would then be brought in close touch with the cream produced by each patron. This plan also enables the manager, if he wishes to do so, to grade the cream, and pay for it according to whether it is first or second class.

When cream collectors are provided with a means of straining each lot of cream, a patron's attention may be drawn to any curd or other matter found in the cream.

Waggons or other vehicles used by cream collectors should be equipped with suitable springs, in order to avoid, so far as possible, agitating the cream sufficiently to cause a partial churning. An undue loss of fat in the buttermilk, and butter with a weak, greasy body or grain, will be the probable result of allowing the churning process to commence while the cream is on the waggons. A light canvas top or covering for the waggons makes a good protection from the sun.

The Collector. The value and importance of a competent, reliable cream collector is too often underestimated by the factory management. In the first place it is necessary that he be strictly honest in his weighing or measuring and sampling. Secondly, he should be so well informed along general dairy lines, and possess such keen sense of taste and smell that the slightest "off" or objectionable flavor would be detected, and a probable remedy for the defect given in a quiet, pleasant, tactful manner. Thirdly, he should be neat and clean.

## Cream Testing.

Cream varies in richness much more widely than does milk. The yield of butter per 100 pounds of cream sometimes goes as low as 12 or 15 pounds, and as high as 45 or 50 pounds.

When operating a hand separator the richness of cream produced may be caused to vary from day to day by a variation in one or more of the following conditions :

1. Speed of Separator. A high speed produces a richer cream than a lower speed.

2. Temperature of the milk at time of separating.

3. The feed of milk to the separator. The faster the milk is allowed to enter the bowl of the separator the lower will the cream test.

4. The amount of liquid used to flush the bowl. The same amount should be used each time.

5. The percentage of fat in the whole milk.

The most accurate method of determining the richness of cream is by means of the Babcock test, which is becoming quite generally adopted by many progressive creamery managers.

The system may be briefly outlined as follows : The collectors are provided with suitable bottles to enable them to take a sample of the cream supplied by each patron. It is well to have the sampling done on some particular basis. The size of sample taken should be proportionate to the weight of cream supplied, say, a fluid ounce for every 30 or 40 pounds cream. Upon arrival at the creamery these small samples should be examined for flavor and acidity, and then be transferred to composite sample jars, to which a small amount of preservative has been added. In this way the samples received during a month may be so thoroughly mixed together that a Babcock test made at the end of the month will give the average fat content of the cream supplied by a patron during that period.

As the Babcock test is based on weight, it is necessary to either weigh the cream or estimate the weight from the number of creamery inches. According to experiments conducted at the Ontario Agricultural College, an inch of average cream in a pail 12 inches in diameter will weigh 4.1 pounds. Thus, if it were found more convenient to measure the cream than to weigh it, the weight could be determined by multiplying the number of inches by 4.1. The number of pounds of cream furnished by a patron during a month, multiplied by the test, or the per cent. fat, and divided by 100 will give the number of pounds of fat which the cream contained.

## Requirements.

1. A Babcock tester. A 24-bottle steam turbine tester is the most satisfactory.

2. A double set of cream bottles (4 dozen), a portion graduated to read 30 per cent. and a portion 40 per cent.

3. An 18 c.c. pipette. A pipette graduated to 17.6 c.c. for milk. and 18 c.c. for cream is a convenience. The careful use of a sensitive scale which will weigh grams insures greater accuracy than measuring.

4. A supply of commercial sulphuric acid, which costs about 65 cents per gallon, or about 1-4 cent per test, and suitable acid measures.

5. A wooden case or rack that will hold 24 cream bottles. It is well to have a separate space or opening for each bottle.

6. Sufficient pint or half-pint milk bottles to furnish a composite sample jar for each patron.

7. Gummed labels bearing the patron's name, or number, should be pasted on the necks of the jars and coated with white shellac. This will prevent the labels being washed off.

8. The sample jars should have sound corks. Turned wooden corks are very satisfactory.

9. A supply of preservative in the form of tablets or powders, consisting of 7 parts of potassium bichromate to one part of corrosive sublimate.

10. Dividers or compasses to measure the fat column.

## Notes.

1. The quantity of preservative required for each sample jar is about what will lie on a ten-cent piece. This should be placed in the composite jar before the addition of any cream.

2. The addition of each subsequent sample of cream should be followed by a rotary motion to thoroughly unite the fresh sample with the preservative.

3. Sample jars should be kept well corked, and preferably in a cool place.

A detailed outline of the Babcock test may be found in Bulletin 114 from the Ontario Agricultural College.

## Oil Tests.

The value of cream for butter making may be approximately estimated by means of the oil test, which is simply a churning process. The outlines of this method of testing are generally known, and call for only a passing reference.

The readiness with which a separation of the oil is effected from the serum is governed very largely by the degree of acid developed in the samples before the commencement of the churning process. This being true, it necessarily follows that ripe or sour samples of cream will give a higher or more satisfactory test than samples of fresh, sweet cream ; thus, the oil test may be said to place a premium on sour cream.

As the Babcock test is rapidly displacing the oil test in cream-gathering creameries, it may be well to become familiar with the relation between the readings of the two tests.

Viewing this relation from the theory of the Oil Test, we have somewhat as follows : A standard creamery inch is one inch of cream (in a pail 12 inches in diameter) testing 100. One inch, therefore, contains $\left(\frac{12}{2}\right)^2$ x 3.1416 x 1 equal to 113 cubic inches. One pound of butter contains about 25 cubic inches of butter oil, which is 22 per cent. of 113. Therefore, any sample of cream which will yield 22 per cent of its volume in butter oil should read 100 and make a pound of butter per inch. A reading of 100 by the oil test would, therefore, theoretically, be equal to 22 per cent of fat.

As viewed from the fat or Babcock test, we have the following : The overrun in cream-gathering creameries will probably range from 15 to 18 per cent. Then 100 pounds fat would yield 116.5 pounds butter.

One pound butter would require 100-116.5 pounds fat.

One inch of cream weighs 4.1 pounds.

Therefore, in order to yield one pound butter per inch :

4.1 lbs. cream must contain $\frac{100}{116.5}$ lbs. fat.

1 lb. cream must contain $\frac{100}{116.5} \times \frac{1}{4.1}$ lbs. fat.

100 lbs. cream must contain $\frac{100}{116.5} \times \frac{1}{4.1} \times 100$, equal to 20.98 lbs. fat. Or practically 21 per cent. fat.

According to experiments conducted at the Ontario Agricultural College Dairy School, the actual percentage of fat in cream yielding one pound of butter per inch is 21.1 per cent.

More attention should be given to the dimensions of the drivers' pails, which have been found to vary from 11 1-2 to 13 inches in diameter. The bottom and the sides should be free from bulges. Weighing the cream insures greater accuracy than measuring. A single beam with a sliding poise, such as butchers use on delivery waggons, answers well.

The relation between the value of a pound of fat and a pound of butter may be found to vary somewhat according to the percentage of overrun obtained.

With an average overrun of 16.5 per cent. and butter worth 17 cents per pound, the value of a pound of fat may be estimated as follows :

A 16.5 per cent overrun would prove 100 lbs. fat to yield 116.5 lbs. butter.

116.5 lbs. butter at 17 cents equals $19.805, then 100 lbs. fat must be worth $19.80 ; therefore, 1 lb. fat must be worth $\frac{19.80}{100}$ equal to 19.8 cents.

If fat were worth 17 cents per lb., the value of 1 lb. butter would be estimated as follows :

100 lbs. fat at 17 cents, $17.00 ; 100 lbs. fat will yield 116.5 lbs. butter ; therefore, 116.5 lbs. butter are worth $17.00, then 1 lb. butter is worth $\frac{17.00}{116.5}$ equal to 14.58 cents.

Assuming the average overrun in cream-gathering creameries to be 16.5 per cent., the following relation will be found betwen the price of fat to the patron, and the price of butter according to the actual yield (not necessarily according to the oil test) :

| Value of 1 lb. butter. | Value of 1 lb. fat. | Value of 1 lb. fat. | Value of 1 lb. butter. |
|---|---|---|---|
| cents. | cents. | cents. | cents. |
| 15 | 17.47 | 15 | 12.87 |
| 16 | 18.64 | 16 | 13.73 |
| 17 | 19.81 | 17 | 14.59 |
| 18 | 20.98 | 18 | 15.45 |
| 19 | 22.15 | 19 | 16.31 |
| 20 | 23.32 | 20 | 17.17 |
| | | 21 | 18.02 |
| | | 22 | 18.87 |
| | | 23 | 19.73 |

## Pasteurizatign.

The quality of butter produced by cream-gathering creameries would be improved by the adoption of pasteurization. This treatment, however, has proved relatively more beneficial to sweet cream than to cream which has been allowed to ripen. The pasteurization of ripe cream may be considered to be yet in an experimental stage.

The chief advantages of pasteurization are :

1. A butter of mild flavor may be produced, and food flavors largely overcome.

2. Better keeping qualities may be imparted to the butter.

3. Greater uniformity obtained in the product.

The following disadvantages are found :

1. An increase in the cost of manufacture, which may be accounted for in the cost of the outfit, labor involved and the expense of fuel.

2. The absolute necesssity for good facilities for cooling. Where either water or ice is scarce, this adds considerable to the cost of manufacture. A pasteurizing plant is not complete without an effective continuous cooler.

The addition of from 10 to 20 per cent. of good culture will improve the butter made from pasteurized cream. As this increases the volume of cream for churning, it is well to have the fat content of the cream intended for pasteurization not lower than 30 per cent.

## Churning.

The fat content of gathered cream is usually so low that a high churning temperature is necessary. This tends to cause an undue loss of fat in the buttermilk, as well as soft butter, which is likely to retain a high percentage of caseous matter and moisture.

Other conditions causing a loss in churning are : Making a churning from lots of cream which differ in temperature and degree of acidity, and also filling the churn too full.

The buttermilk should be allowed to drain well from the churn. It is well to add a pail or two of brine at this stage. Churns should be levelled to allow a free outlet.

Wash with water at a temperature which will give the butter the proper consistency for working and expelling the surplus moisture. It is well to give butter intended for export two washings.

Salting. Salt which has been sifted and is free from foreign flavor should be used in the proper proportion to meet the requirements of the markets. Care should be taken to distribute it uniformly.

Sometimes a preservative in the form of boracic acid in the proportion of one-half per cent. is used to improve the keeping quality of saltless butter.

Working. A more uniform distribution of the salt may be obtained by giving the churn a few revolutions before placing the rollers in motion. If, after partial working, the butter can be allowed to drain a short time without undue exposure, the more complete will the process be.

Packing. Butter intended for the export trade should be solidly packed in clean, tight packages, which have been well coated with paraffine, and lined with heavy parchment paper. If soaked several hours in a strong brine, to which formalin has been added there will be little tendency to mould. Care is necessary to insure a smooth finish without causing a greasy appearance on the surface. The paper ends, if kept moist, may be neatly and closely folded over the top of the package, so as to form a seal, thus excluding the air.

The length of time during which butter will retain its fine aroma depends very largely on the temperature of the storage in which it is held. A temperature not higher than 28 or 30 degrees F. should be maintained when butter is being held for two weeks.

A cold storage requires close attention in order to keep it clean and dry, and to insure a uniformly low temperature. The extreme variations in temperature may be readily noted if a self-registering maximum and minimum thermometer be kept in the cold storage.

It is not wise to hold butter more than a week in the average creamery cold storage. The depreciation in the actual worth of the butter usually more than offsets any rise in price.

## The Creamery Building and Machinery.

The building should be neatly and substantially built, preferably of cement, brick or stone. If built of wood, the walls should be well insulated by the use of four to six thicknesses of lumber, two to four thicknesses of good building paper, and at least two "still-air" spaces. The outside should be neatly painted some light color, which will cause it to be cooler in summer. The floors should be made of cement. A wooden floor should not be used in a creamery, as it is almost impossible to prevent its leaking, and so harboring decaying organic matter. Old wooden floors should be replaced with cement as soon as possible. The cement should also extend up on the walls for at least six inches.

The ceiling of the making room should be at least twelve feet high. The inside of the creamery and cold storage should be coated with whitewash once a year. If not whitewashed, it should be painted, but the cold storage should be coated with shellac and not paint, owing to the smell from the paint which may taint the butter. When troubled with mould on the walls they should be thoroughly cleaned, then be sprayed with a solution of one part bichloride of mercury in one thousand parts of water.

The cream vats should have plenty of space for water and ice around the sides for cooling. The combined churn and worker saves labor, time, floor space, pulleys and belting, and can be recommended to those purchasing new churns and workers. All the machinery in a creamery requires extra good care, as otherwise it deteriorates in value very rapidly.

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ONTARIO AGRICULTURAL COLLEGE

**BULLETIN 136**

Some Bacterial

# Diseases of Plants

Prevalent in Ontario

BY

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Bacteriological Department

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Ontario Agricultural College and Experimental Farm

# SOME BACTERIAL DISEASES OF PLANTS PREVALENT IN ONTARIO.



12 Illustrations (Figs. 3-12 original F. C. H.)

## FIRE BLIGHT.

"That species of blight which is sometimes called the 'fire blight, frequently destroys trees in the fullest apparent vigor and health, in

Fig. 1.—A pear orchard badly infected with Fire Blight.

a few hours turning the leaves suddenly brown, as if they had passed through a hot flame and causing a morbid matter to exude from the pores of the bark of a black *ferruginous* appearance ; this happens throughout the whole course of the warm season—more frequently in weather both hot and moist." So wrote William Coxe in a book on the "Cultivation of Fruit Trees," published in 1817, which is said to be the oldest American book on fruit culture.

Nearly forty years before this we have a record of the disease mentioned in a letter written by one William Denning, who first saw the disease in the Highlands of the Hudson, in 1770. He described the disease fairly well, and thought it was due to a borer in the trnnk of the tree.

From 1817 to almost the present time, we find in horticultural literature many theories as to the cause of the blight. It would be tedious to give an account of all the different theories put forward by various writers during this period. The most diverse views were entertained as to the cause of the disease, and it was a constant topic for discussion in the horticultural journals and societies. These discussions were so wearisome and so barren of results that the Western New York Society resolved that the subject should not be discussed at their meetings unless some one had something entirely new concerning the disease to communicate.

Amongst the different theories put forward to explain the cause of pear blight, we may mention the following:

1. Insects.

2. Rays of the sun passing through vapors.

3. Poor or deleterious soil.

4. Violent changes of the temperature of the air or the moisture in the soil.

5. Sudden change from sod to high tillage resulting in surfeit or overplus of sap.

6. The effects of age ; old varieties being most subject to it.

7. Autumn freezing of unripe wood, which engendered a poison which destroyed the shoots and branches in the following season.

8. Electricity, or atmospheric influence.

9. Freezing of the sap, or freezing of the bark.

10. The heat of the sun assisted by rain-drops acting as lenses causing the scalding of the sap and bursting of the cells.

11. Fermentation of the sap.

12. The absence of certain mineral matters in the soil.

13. An epidemic transmitted from place to place by the air.

14. Fungi.

Each of the above theories was sustained by various writers, and it may be of interest to note that Henry Ward Beecher was an advocate of the theory that the cause of blight was due to the autumn freezing of unripe wood.

A. J. Downing, the distinguished author of "Fruits and Fruit Trees of America," applied the name "Frozen-sap blight" to the disease. His theory was that the disease was due to the freezing and thawing of sap. The sap thus lost its vitality, became dark and discolored and poisonous to the plant.

Thomas Meehan, editor of the "Gardeners' Monthly," supported the idea that fungi were the cause of the disease; but no tests were applied to prove that the inoculation of these fungi into healthy trees would cause the disease. It was not until the year 1878, when W. T. Burrill, Professor of Botany in the University of Illinois, announced to the Horticultural Society of that State the discovery of bacteria, apparently connected with the disease. Burrill also proved that the disease was infectious, and could be communicated to healthy limbs by inoculation, using the gummy exudation from an affected tree as a virus. Not only was he able to produce the disease in pears, but also in apples and quinces. Dr. J. C. Arthur, Botanist of the New York Experimental Station, subsequently confirmed Prof. Burrill's results, and thoroughly established the fact that a certain species of micro-organism, named by the discoverer *Bacterium amylovorum* or the starch destroying bacterium, was the sole cause of the disease.

*Geographical Distribution.* This disease is peculiar to North America. So far it has never been recognized in Europe. Professor Budd, of Iowa, who is familiar with the disease as it occurs in North America, has inspected the orchards of Europe and states that no trace of fire blight of pear or apple trees can be seen in Europe. It is also unknown in New Zealand and Australia. In North America, the blight extends from New York to California and from the northern counties of Ontario to Texas.

Dr. Beadle, in a sketch of the history of the disease in Ontario, states that, "In the early days of fruit-growing in the Niagara district we had no pear tree blight nor apple tree blight. With the advent of what people termed grafted fruit there came, after a few years, 'blight' on the pear tree." "By the year 1840 it had spread considerably." N. J. Clinton, of Essex County; S. Hunter, of Oxford; E. D. Smith, of Wentworth; Stone and Wellington, of Welland; R. Hamilton, of Argenteuil, reported its presence in their respective counties about 35 years ago. The colder parts of the Province have suffered as severely from the disease as the more favoured districts. The orchard of the Dominion Experimental Farm, at Ottawa, has been attacked, and the 140 Russian variety of apples cultivated there have suffered severely. In warmer districts, however, the disease has been much more severe. Whole orchards have been completely destroyed in the State of Texas, and certain pear-growing districts in that State have been practically ruined by this parasite.

*Losses.* No statistics are available to give us an idea as to the amount of loss to fruit growers from pear blight, but a few references to losses by this destructive disease will help to give us an appreciation of the subject. Coxe, in 1817, reported that he had lost upwards of fifty trees in twenty years. In the years 1826, 1832, and 1844 there was an increased prevalence of the disease, and few pear orchards escaped without partial or total loss of many trees and some orchards were quite destroyed. Downing called it the "monstrous malady of the pear." Lyons stated, as the opinion of many cultivators in the State of Michigan, that "The pear tree cannot be grown with financial success on account of the blight." Hallam, in 1882, reported that, "In Southern Illinois, pears have failed—utterly failed—so that none are now cultivated for market. The blight has destroyed the trees, branch and root;" while A. Noice of the same State, doubted "if one-tenth of the pear trees that are planted lived ten years on account of this destructive agent." E. H. S. Dart stated that the severities of winter were not so much to be dreaded as the ravages of blight. He had in 1874 one to two thousand trees affected. Dr. P. A. Jewell, in 1876, lost 10,000 Tetofsky apple trees by it. Bailey, of Cornell, declared that fire blight was undoubtedly the most serious disease with which the quince grower had to contend. It is the same disease which is so destructive to pear orchards in certain years and to certain varieties of apples, particularly the crabs. Selby, of Ohio, reported that the disease ranks among the most destructive known to the orchardist in his State. Chester, of Delaware, announced that pear blight was of unusual severity during the season of 1901 and caused much alarm because of its rapid spread through the orchards of the State. In 1895 its ravages were most severe on apple trees in the vicinity of Hamilton and Burlington Bay. J. Craig gathered information as to the character of injury of the disease from fruit growers throughout this Province and a number of these state that the injury was very severe.

These citations are enough to show that the disease is of special economic importance and greatly dreaded by many fruit growers.

*Symptoms.* The first indication of fire blight is seen either in the browning and subsequent blackening of the leaves or of the young twigs or of the tender shoots. When the twigs or shoots are the principal parts affected the disease is spoken of as twig blight. Pears show the presence of the disease more frequently by the blighting and blackening of the leafy tufts of the spurs, and show it especially by the darkening of the blossom clusters on the larger clusters, while, later, the branches themselves become blackened The progress of the disease is always downward—an inch or more each day, depending upon the season, until the larger branches are infected. In the more susceptible varieties it spreads more quickly, involving the whole tree; but in the more resistant varieties the progress of the disease is not so fast. When the disease is active the bark of the diseased branches cracks, and a thick, blackish, gummy fluid exudes, and later the infected bark becomes hardened, dry and shrunken. The disease occasionally appears on the larger branches and trunks of fruit trees when these have been bruised or otherwise injured, when its appearance is similiar to the injury known as "sun-burn" or "sun-scald." This disease of the trunks or larger branches is sometimes spoken of as "body blight" or "rough bark." The inner bark and cambium layer of the limbs and trunk are the most important parts of the tree killed by the blight. Instances are known of its attacking the fruit, producing watery ulcers accompanied by brown discoloration and decay. The disease may be known by its peculiar odor, said by some writers to resemble putrefaction.

When the disease is in progress, the discolored blighted portion blends gradually into the color of the normal bark, but when the disease has stopped there is a sharp line of demarcation between the diseased and healthy portions. (Waite).

*Microscopic Appearance of the Diseased Tissues.* The most conspicuous change in the tissues affected with the blight is the disappearance of the stored starch, and on account of this peculiarity the organism has been named the "starch destroying bacillus" (*Bacterium amylovorum*). The germ penetrates from one cell to another and produces a gummy or mucilaginous matter which is found on the exterior of the affected parts. The microbe is found, as a rule, only in the inner bark and the actively growing tissues (called the cambium, which produces wood on the inner side and bark on the outer side). The organism is unable to grow when the tissues are lignified or woody.

*Life History of the Pear Blight Germ.* The organism which produces the disease is a small motile bacillus, which increases with great rapidity in the succulent parts of affected trees. (Fig. 4). The microbe is of microscopic size, so small that 25,000 placed end to end would only measure an inch. They are able to live and multiply in the nectar of the blossoms, from whence they are carried to other flowers by bees and insects which visit the blossoms for honey and pollen. From this locality the germs extend into the tissues and then downward into the branches by way of the inner bark, girdling the limbs and causing a large amount of damage. The blight germ also gains entrance to the plant through the tips of growing shoots, thus producing twig blight. The organism is not killed by the winter frosts, but lives in the bark in a dormant condition until spring. As soon as the plant tissues become gorged with sap in the spring the microbes, which have remained alive all through the winter, start to grow and extend into the new bark. This new blight which develops in the spring can be recognized by its moist and fresh appearance from the blighted, dead and dried bark of the previous summer. A large amount of gum is exuded from the affected bark, and runs down the tree and attracts to it bees and other insects, which carry the microbes to the early blossoms, and from these first flowers it is carried to others, and thus the disease extends.

The germ has never been discovered in the soil, although careful search has been made ; hence the importance of recognizing the winter form of the disease, for if these affected portions of the tree are cut out and destroyed, the pear blight question is solved, for without the microbes there can be no disease.

*Conditions Affecting the Spread of the Disease.* Fire blight differs in severity in different localities, and there are a number of conditions which affect the character and progress of the disease.

Every tree of the pome family is subject to the blight, but pears and quinces are more susceptible than plums and apples. The mountain ash, service berry and hawthorn are frequently diseased, but not to such an extent as the first named trees. There is a difference in the susceptibility of varieties. Thus, among pears, Clapp's Favorite, Flemish Beauty, and Bartlett are more liable to the disease than Keiffer and Duchess, and amongst apples, the Crab varieties are the least resistant.

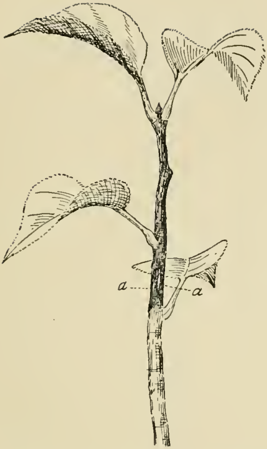


Fig. 2*a*.—Showing the result of inoculating a terminal shoot with a pure culture of the Fire Blight organism by puncture at the point *a*.

Fig. 2*b*.—Showing the blighting of a terminal shoot by inoculation of the terminal bud with a pure culture of the Fire Blight organism. (After Chester).

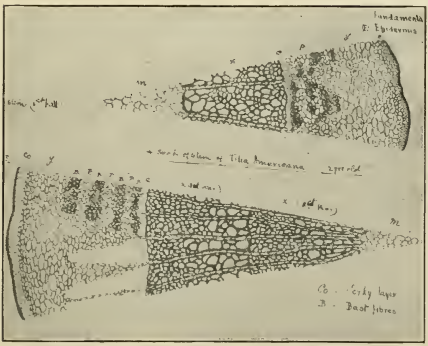


Fig. 3.—Cross section of a one and two year old stem. Fire blight bacteria grow in the cambium (c) and inner bark (F). E—epidermis. Co—Corky layer, B—Bast fibres, P—Parenchyma, C—Cambium. X—Xylem or woody tissue. M—Medulla or pith.

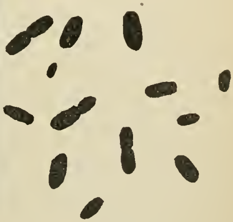

Fig. 4.—Fire Blight bacteria (B. amylovorum.) x2000,

Climatic conditions influence the disease; warm, moist weather with much rain favour it, whilst bright, dry, sunny weather tends to check it.

High cultivation, rich soil, heavy manuring, free use of fertilizers, heavy pruning, or any other treatment which has a tendency to induce new and succulent growth, favors the disease, as the bacteria grow with far greater rapidity and penetrate more quickly from cell to cell when the tissues are gorged with sap. Insects are more partial to young succulent shoots and leaves, and the bites and punctures of such insects whose mouth parts may be contaminated with pear blight germs often serve to infect the tree.

It is thus manifest that healthy, thrifty, vigorous, well fed and well cultivated trees are more liable to the disease than others, and hence the severity of an attack of fire blight may be lessened by conditions which are under the control of the grower.

*Treatment.* The treatment of fire blight is of two kinds—that which is designed to put the tree in a condition to withstand the attack of the blight microbe, and those methods which aim at the extermination of the causal bacterium. Unfortunately all methods which are used for hindering the attack of the microbe consist of restraining the full development of the tree, and hence any such system of procedure should not be followed unless an orchard is very badly attacked.

High cultivation with pruning and the other conditions already mentioned as predisposing trees to blight should be avoided, but the trees should be allowed to ripen the wood, and in order to do this the fruit grower must use any method which will check the amount of moisture in the soil—for instance, by the growth of a clover crop.

The fire blight organism cannot be exterminated by spraying, as the microbe lives in the tissues beneath the outer bark, and it is impossible to reach it with any spraying solution, for, unless the bacteria come into contact with the germicide, spraying is ineffectual.

There is, therefore, but one remedy, to cut out and burn the affected parts of the tree. It is very necessary when cutting out a diseased branch or twig to cut well below the discolored portion, as the bacteria are in most cases far below the discolored portion, the discoloration not being produced immediately upon the appearance of a few bacteria, so that if only the discolored portion were cut off numbers of bacteria would still be left in the stump, and these would continue to multiply, and the disease would soon be evident again.

Cutting of affected parts may be done at any time in the winter and spring, but it is not advisable to cut in the growing season, as fresh cases may be constantly occurring, and these, owing to lack of sufficient development, would not be seen.

The best time for cutting out affected branches is towards the fall, or when the trees have stopped forming new wood, when most of the blight has developed, and when the contrast between the discolored leaves and branches and healthy tissues is easily seen

Trees should be carefully inspected for blight during the winter, and in spring before the blossoms come out, in order to destroy any affected parts that may have been missed at previous inspection.

All trees of the pome family in the vicinity should be examined as well, as these, if blighted, may serve to reinfect an orchard which has been carefully treated.

In cases where the bark of the trunk is affected, it can be cut out and the wound covered with a lead and oil paint. The cut surface of the branches over one-half inch in diameter should also be painted.

## A BACTERIAL DISEASE OF BEANS.

Lima beans are not grown commercially in Ontario. Wax beans are grown in gardens and for canning. Field beans are grown extensively in the lake counties of Essex, Kent and Elgin, Blenheim and Ridgetown being centres of the bean industry.

A bacterial disease of beans is causing loss and injury in nearby bean-growing sections of the United States, from New Jersey to Michigan, and it is probable that it occurs in this Province. We have made some study of the disease under field conditions in Michigan and in our laboratory at the College.

The disease usually begins at the margin of the leaf, or where the leaf has been injured or torn by insects, wind, or hail. Here a yellow spot appears, and the green of the leaf is destroyed. The spot increases rather slowly, and the diseased tissues become brown, especially the minute veins, which become almost black.

This diseased part of the blade turns dry and brittle in the sun, and soft in the rain, and it may be broken away, leaving ragged holes and torn margins. The whole leaf may die and fall to the ground or remain withered on the stem. The disease enters the stem by way of the leaf stalk, and advances in the stem to other leaves and to the young pods. In severe cases the pod may wilt and die, and, on opening it, the half-grown seeds will be found shrivelled and discolored. Most of the affected pods, however, reach full size, and the beans may be apparently sound or only slightly discolored at the seed scar, or they may be much discolored. The whole plant does not usually die outright, but lingers through the season

If we tear out a bit of tissue from a diseased spot in the leaf, crush it on clean glass, and examine it under the microscope, we shall find bacteria in very great numbers; they are so numerous that the diseased tissue seems to be a mass of bacteria, and all apparently of one kind—small, short rods, single, or joined end to end in twos. This germ, and the disease caused by it, were first described by Erwin Smith, and the name given to it is *Pseudomonas phaseoli*.

Fig. 5.—The bean plant inoculated with the bacillus which causes the disease. Showing the wilted leaves.

With proper care, we may tear open a stem, take a bit of diseased tissue, crush it in melted gelatin; and pour the whole into glass dishes. Here, the gelatin becomes solid, holding each germ apart from others, where it grows and multiplies, and in four days small, round, yellow spots or colonies appear. On examination these colonies are found to consist of bacteria like those in the diseased plant. We can now transplant a colony to various media and observe its growth in pure culture. By such methods, we have repeatedly got pure cultures from leaf, stem, pod and seed. The bacteria have been obtained alive from the seed coats of beans kept in the dry pods or in sterile test tubes over winter, and the same seeds have then germinated and grown.

During the past winter, we have inoculated more than twenty bean plants growing in pots in the laboratory. The surface to be inoculated was touched with a hot platinum needle and then punctured with a sharp, sterile platinum needle. The needle was then touched into a pure culture of bacteria from the diseased beans and thrust again into the puncture. The puncture was closed and sealed with a loop of sterile, melted paraffin. Other punctures were made and covered in the same way but no bacteria were introduced. Every inoculated plant sickened and the same symptoms developed as were observed in the diseased plants in the field. Numerous check plants remained healthy. Plants inoculated in the stem showed symptoms after two or three weeks. At first, there is a yellow discoloration, spreading slowly from the point of inoculation. As the disease progresses, it enters the leaf by way of the leaf stalk and kills it. Finally, the whole plant may be killed or it may linger alive for months.

Fig. 6.—The bean plant inoculated with the bacillus which causes the disease. Showing the wilted leaves.

The leaf may be inoculated by puncturing the veins, but a better way is to inoculate in the petiolules, or short stalks of the individual leaflets. The disease most affects the woody bundles of leaf and stem, and all the woody bundles of the leaflet converge in the petiolule. A puncture in the petiolule causes no lasting injury but soon heals if no bacteria are introduced.

The needle, which should be fine and sharp, is thrust into the petiolule from its upper end downward. Each of the three petiolules is thus punctured and the culture is then introduced into one or more of the punctures and all are closed with sterile, melted paraffin.

Some time will pass before any symptoms appear. In about three weeks, the inoculated leaflet droops on its stalk and wilts in the sunshine, but apparently recovers at night. There is a yellowing at the base of the blade; this spreads rapidly, following the veins. The affected tissues wilt, and the veins become dark brown. Within five days from the appearance of the first symptoms, the leaflet is dead and dry.

During this time, the leaflets of the same leaf which were punctured but not inoculated remain healthy, and it is nine or ten days, on the average, before the disease reaches them. In a few days more, these leaflets also are dead. The disease now travels down the main leaf stalk and enters the stem, where it progresses slowly from node to node, killing the leaves and finally it may kill the whole plant.

All inoculated plants developed the characteristic symptoms of the disease, and all were, at some period, examined for bacteria. The characteristic bacteria were found in every instance, and in all parts examined which showed the symptoms. Numerous check plants, kept under the same conditions, but not inoculated, showed no symptoms of the disease, but remained healthy and, on examination, no bacteria could be found in their tissues. Plate cultures from the diseased tissues of inoculated plants developed uniform pure cultures of the germ inoculated into them. Sections of the inoculated plants showed characteristic bacteria present within the cells and especially numerous within the woody bundles; the vessels being choked with them and the cell walls frequently dissolved.

## Prevention.

No remedy is known for the disease after the symptoms once appear in the plant. Measures may be suggested, however, to prevent its introduction and spread. Seed containing the bacteria must not be planted. Such seed may be much discolored, may show slight evidence of infection, and for this reason seeds from fields where the bean plants have shown symptoms of the disease should not be planted, even though such seed has been carefully picked over and all discolored beans removed from it. This precaution in the selection of healthy seeds applies with special force to the planting of new fields where beans have not been grown. It is hoped that a method of treating the seed may be worked out, by which the bacteria may be surely killed without injury to the seed. This germ, *Pseudomonas phaseoli*, forms no spores and is readily killed in water heated to only 122° F., for ten minutes, a temperature which dry bean seed can endure for some time without injury. It is readily killed, also, by a solution of mercuric chloride, one part to 1,000 of water.

A field where beans have sickened with this disease is unfit for growing beans for at least one season, as the germs live over at least one winter in the stems and leaves left on the ground. How long such a field may remain infected is unknown, for we do not yet know whether the germs can live and increase in the soil where no beans are growing, although this is probable.

Bean straw from infected fields may be burned. If it is fed to animals or used as bedding, the manure should be returned to the field on which the beans grew, and not spread on fields as yet free from the disease.

This Department will continue its work with the disease, and we hope to make a survey of the commercial bean-growing areas of the Province about the time of bean harvest this season. We shall be glad, at any rate, to examine diseased bean plants and seeds intended for planting.

## SOFT ROT OF WHITE TURNIPS, CAULIFLOWERS, CABBAGES, ETC.

During the last few years we have examined a number of the soft rots, caused by several different kinds of microbes. In one case we made a special study of the causal organism, which proved to be a new species. Considerable study was devoted to a rot of Swedes which has caused much loss to farmers in different districts of the Province. We also found that one of the causes of a soft rot of celery was due to a common soil organism which heretofore had not been found able to produce disease in plants.

The soft rot of white turnips, cauliflowers, etc., has been rather common during the last few years. In 1901 much damage was done to market gardens in the vicinity of Guelph, and wherever white turnips were grown there was considerable rot during the season of 1901.

*Cause.* This soft rot is caused by a microbe—a bacillus or rod-like organism (scientific name, *Bacillus oleraceae*) which increases very rapidly when once it has gained admission to the plant. It secretes a substance which has the power or property of dissolving the cell wall of the plant. The cells are thus separated from one another, break down, and a soft, pulpy mass is the result. From this action of the microbes, the common name "Soft Rot" has originated.

*Symptoms.* The character of the rot is similar in all plants that are attacked. In the cauliflower, the head or edible part breaks down into a soft pulpy mass, brown to black in color, usually with an objectionable smell. Cabbages behave in a similar manner. In turnips, the globular root is the portion of the plant that shows the most decay. The rot is brown in color, very soft, and with a dis-

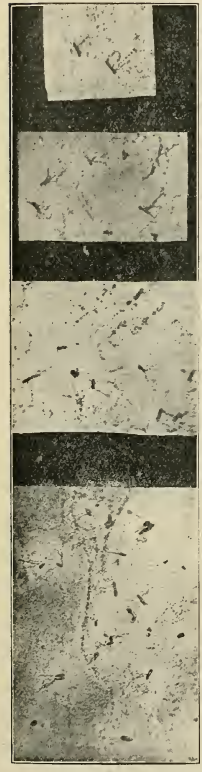

Fig. 7.—*B. oleraceae*. The flagella stained by Van Ermegen's method. The bacteria were taken from an agar culture 18 hours old.

Fig. 8.—A healthy cauliflower plant; inoculated and grown under the same conditions as the inoculated plants.

Fig. 9.—Cauliflower plant inoculated by placing a piece of softened tissue, taken from the interior of an affected inoculated petiole, on the surface of the healthy flower. The flower is reduced to a pulpy, black mass. Five days from time of inoculation.

agreeable odor. The turnip leaves have a wilted appearance, owing to the fact that their supply of nourishment is cut off.

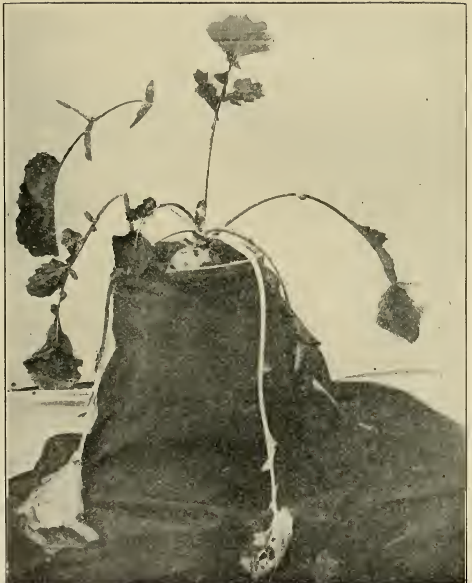

Fig. 10.—A white turnip plant inoculated at the crown from a pure culture of *B. oleraceae* by means of two needle punctures. The photograph shows the plant nine days after inoculation.

Fig 11.—Cross section of part of the petiole of a diseased cauliflower inoculated with a pure culture of *B. oleraceae*. Note the bacteria in the intercellular spaces and their penetration along the middle lamella.

## Conditions Affecting the Spread of the Disease.

1. *Meteorological Conditions.* Warm weather, combined with excessive moisture both of the soil and of the atmosphere, and the fact that transpiration is checked by this condition, undoubtedly play an important part in the spread of the rot amongst cauliflowers and turnips. Those seasons which are warmer and moister than the average predispose plants to rotting.

2. *Rankness of Growth.* The weather conditions above mentioned, and the plentiful use of manure by market gardeners and good cultivation, favor very quick, rank growth. The plants most affected are large and heavy, with many leaves shading the surrounding soil, thus conserving moisture and promoting quick growth.

3. *Abundance of Insect Pests.* The disease is chiefly spread by means of infection by wounds, and under field conditions these are usually produced by insects, especially the cabbage worm and turnip beetle. A careful examination of very many plants show that one or more insects are present on each plant. Slugs also do considerable damage. Ants and other insects swarm around turnips, eat the rotting pulp and no doubt serve to carry the germs to other plants.

4. *Injury from Planting, Cultivation, or Wounds.* Leaves of turnips are frequently bruised or injured during cultivation by either hand or horse hoes. Cauliflowers may be injured during planting out and the infecting organism brought into contact with the broken surface. In cases of very rank growth, heavy wind accompanied by rain may cause leaves to be broken off and thus afford bacteria a chance to penetrate into the plant tissues. Many gardeners trim their cauliflowers on the field, and when these are infected they carry the disease on to another season. The same ground is often used, year after year, for the same crops, a dangerous procedure when disease is present, as it is likely to carry over the trouble to other years.

5. *Susceptibility of Varieties.* Some varieties of turnips rot far more easily than others. Thus, the Yellow Aberdeen Green Top, the Yellow Globe, All Gold, etc., are usually far more rotted than a number of other varieties.

## Prevention.

It is impossible to spray with any of the ordinary fungicides for this disease as the organism is in the interior of the plant, and the spray is only effective when it is actually brought into contact with the organism ; hence spraying is of no use, and efforts are therefore to be directed towards prevention rather than cure. The following methods will serve to check the disease:

1. The use of rotation by which other crops are grown on infected soil for a number of years.

2. Control of insect pests as these serve to spread the disease.

3. In the case of cauliflowers and white turnips, destined for immediate consumption, early harvesting of the crop is recommended, as the disease is worse when the plants are approaching maturity.

4. In cases where the turnips are stored they should be placed in a well-ventilated and dry cellar in which the temperature can be controlled. The minimum temperature for growth of the germ is about 45° ; hence if the cellar can be cooled to this temperature no rot will take place.

5. The planting of immune varieties. There are a number of varieties which do not seem subject to the rot, thus the Jersey Navet is almost immune and, ander field conditions, the following varieties show less than 5 per cent. of rot: Greystone Improved, Purple Top Mammoth, Early American Purple Top, White Egg, White Lily, Red Top.

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## SOFT ROT OF SWEDE OR YELLOW TURNIPS.

This disease of Swedes has been observed in the Province for a number of years. In the year 1896, considerable damage was done to the turnip crop before the time of harvesting by soft rot. In many cases the turnips which had been culled out as unfit for storage were left out in the field and were ploughed down in future cultivation, and thus the soil was infected. The turnip crop of 1902 was also infected with rot. Many farmers estimated their loss that season at about one-third of the entire crop. The disease was particularly bad in the London district.

*Cause.* This rot is also caused by a microbe which has a similar action on the plant to the organism already described as being the cause of the soft rot of white turnips.

*Symptoms.* Growing Swedes affected with the rot are usually distinguished from the sound turnips by the appearance of the leaves. At first the lower leaves become flabby and have a dull green color which gradually changes to a yellow shade as the leaves dry. The lower leaves appear to be the first affected, and the growth continues in the upper or middle leaves as the lower ones drop off, thus producing what is commonly called "necky turnips." The plant by this time is badly dwarfed and the top nearly dead except for two or three stunted, small leaves in the centre of the top. A softening of the tissue of the turnip now appears around the crown of the plant, which continues to increase until the whole turnip becomes a soft spongy mass with a disagreeable odor. The odor is caused by the decomposition of the tissues and the formation of aromatic compounds.

### Conditions Affecting the Spread of the Disease.

The seasons in which this disease was bad were cooler than our usual summer weather, and the amount of rainfall was in excess of the usual amount. In the month of October, 1902, there was a heavy rainfall which probably extended the growing season of the turnip ; and the unripe and damp condition of the turnips when harvested, together with the warm weather which followed the storing of the turnips, proved very favorable for the development of the disease.

Fig. 12.—Swede Turnip affected with soft rot.

Other conditions affecting the spread of the disease are the same as those mentioned above.

### Prevention.

If roots are properly ripened and cured they are not so liable to the rot when stored as are the roots which are either unripe or improperly cured, or both. When roots are taken from the field in a wet condition and directly stored in the cellar more rot is liable to be found. The temperature after the crop is stored has also a considerable effect upon the growth of the rot if it should happen to be present in the roots and a great deal of rot in stored roots would be avoided if the cellars in which the roots were stored were properly ventilated.

If the cellar adjoins the stable, a great deal of dampness gets into the cellar from the moisture from the cattle stable. This not only adds moisture to the air of tho cellar but also raises the temperature.

Affected turnips should not be left out on fields to spread the disease to a following season ; but should be gathered and burned, and in the same way the roots in which the rot develops after harvesting should be burned and not thrown upon the manure heap to infect the manure first and then the field to which the manure is applied.

The harvesting of the root crop should be delayed as late as possible in order to allow the crop to become thoroughly ripened. After pulling, the roots should be allowed to dry off before being stored.

## A ROT OF STORED CELERY.

Celery may be dug in the fall and stored in a cellar to be used during winter and spring. It is usual to pack it closely, with the roots in soil which is kept moist. With right conditions of moisture and temperature the celery keeps well until spring, but, if the soil is wet, and the temperature varies, and, especially, if the celery freezes and thaws, it will decay.

Decay follows close upon death. The bacteria and moulds are its active agents. They are always present in the soil in which the celery grows, and in the soil in which the roots are packed, and there are no practicable means by which they can be kept away from the p'ant ; neither can they be killed without killing the plant. It remains then to keep the celery alive and in health so that it can resist the invasion of the bacteria. A constant temperature, a little above freezing, keeps the celery alive without growing, and keeps the bacteria in check, for they also become dormant at low temperatures, and increases slowly, or not at all. If the celery freezes it becomes so much dead matter without resistance, fit food for bacteria, and, as soon as the temperature rises, the celery rots.

This was observed in some celery stored in the cellar of the Horticultural department of the Ontario Agricultural College during the winter of 1903-4. The celery tops showed signs of having been frozen, but, as the temperature continued low, it remained sound within, the outer leaves and stalks only showing signs of decay. On staining the decayed tissue, bacteria were found in large numbers, and, on making plates from the inner parts of the decayed stems, many colonies developed. The plates were usually pure cultures, or almost pure cultures, of *Ps. fluorescens*, and two varieties of it were recognized. This is a rod-shaped organism, and is one of the commonest microbes found in water and soil; it is not usually associated with plant diseases. Two varieties of the germ were recognized, one from stems becoming brownish to amber in color in rotting, and the other from stems showing a greenish-blue color in rotting. Both varieties liquefy gelatin with green-yellow fluorescene. Some fresh plants of celery were obtained, and the outer leaves were cut away. The inner leaves were washed under the tap, and covered with mercuric chloride solution, one part to a thousand of water, then rinsed in sterile water and each stem put into a large sterile test tube containing a little sterile water in the bottom. In three weeks, four out of fourteen stems so prepared showed signs of rotting, but some remained sound after a month, and were then inoculated with pure cultures originally isolated from the celery. Some of these stems in test tubes had been standing in the sunshine and had regained their green color. To inoculate them a sterile platinum needle was dipped into the pure culture and thrust into the stem. After one day at room temperature the rot was sometimes evident, and, in about four days, juice from the rotting stem had accumulated in the bottom of the test tube, and the stem was softened throughout so that it could be shaken down into a soft pulp in the bottom of the test tube. Plates from such inoculated and rotted stems developed colonies of *Ps. fluorescens* in pure cultures.

While the weather continued cold the celery in the cellar remained sound, although it developed a sweet taste; but, when warm weather came in early spring, what had not been consumed, rotted.

By such study we learn that bacteria cause decay, and that decay takes place under conditions in some measures known to us and under our control. To keep celery well it should be packed with the roots in clean soil. For this purpose it is best to use the humus, or muck soil, in which the celery is commonly grown. The soil in which the roots are packed should be kept moist, but not wet, with good water. The cellar or storage room should be kept at a uniform low temperature, a little above freezing. Free ventilation should be provided, both as a means of regulating the temperature and for the health of the plants. It should be remembered, also, that celery kept in a close, foul atmosphere becomes tainted.

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# ONTARIO AGRICULTURAL COLLEGE.

**Bulletin 137.**

# A Bacterial Disease of Cauliflower
*(Brassica oleracea)*
# and Allied Plants

BY

F. C. HARRISON, Bacteriological Department.

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**Bulletin 137.** **August, 1904.**

Ontario Agricultural College and Experimental Farm

# A Bacterial Disease of Cauliflower (Brassica oleracea) and Allied Plants.

By F. C. HARRISON, Professor of Bacteriology.

In the summer of 1901, a market gardener, in the vicinity of Guelph, who made a specialty of growing cauliflowers, complained of a disease which was affecting his plants. Shortly afterwards the cauliflowers in the garden department of the College were also found to be infected, while further investigation in the neighborhood showed that a disease, or rot, of cauliflowers, cabbages and white turnips was quite general and had done considerable damage to these crops.

In the case of the market gardener referred to, more than half of his plants were affected, while in the College garden, about 5 per cent. of the plants were diseased.

Some 40 varieties of white turnips were tested on the trial grounds at Guelph, and most of them were more or less affected with the rot, the percentage of decayed roots varying with the variety, in some cases reaching as high as 64 per cent. The few farmers in the Province, who experimented with the varieties of white turnips that were sent out from this Experiment Station, reported a considerable amount of soft rot.

Later in the same summer I visited a number of farms in the vicinity of Woodstock, and found a varying percentage of white turnips rotting in the fields, although the Swede turnips were not affected, and from conversation with a number of farmers who visited us during the past season, I also gathered that wherever white turnips were grown there was considerable rot during the season of 1901.

## Pathogenesis.

In order to positively demonstrate that the organism isolated from the cauliflower and turnip was the cause of the rotting, the usual requirements were worked out.

1. *Constant association of the Bacillus with the Disease (named Bacillus oleraceae and subsequently described).*

The same bacillus was isolated from diseased cauliflowers from the vicinity of Guelph, and from the garden department of the

College; from diseased white turnips of several varieties taken from the trial grounds of the Experimental Department, and from other parts of the Province, and also from cabbages growing next to the diseased cauliflowers in the garden department

This organism was also found in large numbers on the plate cultures, sometimes in pure culture, at other times in mixed culture, the most common contaminating organism being the *Bacillus fluorescens liquefaciens*. The rot bacillus was so numerous that a loopful of the rotted or pulpy tissue had to be very largely diluted in order to reduce the numbers on the culture plates to about 60-100 colonies per plate. In all these cases, no fungi were present and no mycelium was ever seen.

W. Lochhead, Professor of Biology at the College, who also examined some of the cauliflower material, was also unable to find any mycelium of fungi.

2. *Isolation of the organism and study in pure cultures.*

The isolation of the causal bacillus was quite easy, as it grew well in ordinary 10 per cent. beef peptone gelatine. The bacillus, whether isolated from diseased cauliflower, turnip or cabbage, or from different plants and varieties of the above plants, showed the same characteristics when grown on various media. Comparative studies of the various germs, isolated from different sources, were made, but no essential morphological or cultural differences were noticed. Bouillon,* 10 per cent. gelatine, agar, milk, potato, raw and cooked, raw cabbage stems, raw turnip and raw cauliflower were used in this comparative study.

3. *The pure culture of Bacillus oleraceae when introduced into susceptible plants produced the characteristic symptoms of the disease.*

A series of inoculation and cross inoculation experiments were made in order to substantiate the relation of the bacillus to the disease. Thus a series of cauliflower, turnip and cabbage plants were inoculated in the following manner :—

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*These terms, when not otherwise stated, refer to media prepared in accordance with the recommendations of the Laboratory Committee of the American Public Health Association.

Inoculated with a pure culture of the *Bacillus oleraceae* from

| — | Cauliflower. | Turnip. | Cabbage. |
|---|---|---|---|
| Cauliflower...................... | x | x | x |
| Turnip ........................... | x | x | x |
| Cabbage.......................... | x | x | x |

Positive results were obtained in each case, with the characteristic symptoms of the disease, viz., rotting and blackening of the leaves and stem.

These plants were all kept under favorable conditions for the spread of the rot. These conditions are described at length later on in this paper.

4. *The diseased, or rotted, tissues contained the Bacillus oleraceae in huge numbers.*

While their distribution and effect on the tissues was the same as that met with under ordinary field conditions, and re-isolation proved beyond doubt that it was identical with the organism which was inoculated.

5. *The chemical products of the organism also produced the characteristic symptoms of the disease.*

The bacillus was grown on raw turnips and cabbage until all the tissues were completely rotted, and the rotted material was then pressed and the juice extracted and forced through a Chamberland filter. This filtrate, which was found to be sterile, produced softening and rotting when placed on cut surfaces of raw potato, turnip, cauliflower and cabbage. Control cultures of these vegetables, kept under the same conditions as the inoculated slices, remained sterile.

## Pathological Histology.

A microscopical examination of the soft pulp from cauliflowers and turnips showed the presence of enormous numbers of bacteria. No mycelium or fungus spores were present. The bacteria. were actively motile. In fresh preparations, free plant cells were visible and many were much disorganized.

A large variety of diseased tissues were fixed in a saturated solution of corrosive sublimate in 94 per cent alcohol, and subsequently imbedded in paraffin. Some 400 sections were cut from various diseased parts of cauliflower and turnip plants, and were stained by various methods. The most satisfactory results were obtained by staining over night in carbol fuchsin, washing out the surplus stain first with water, and then with 97 per cent. alcohol, clearing in oil of cloves and mounting in Canada balsam. A number of sections were also stained with anilin blue. The latter method gave fair results; but the former method was the more satisfactory.

Completely rotten cauliflower or turnip was difficult—in fact it was almost impossible—to imbed in paraffin, as the whole mass fell to pieces when thrown into alcohol. Portions of petiole, stem, or flower of cauliflower, where the disease was just starting and pieces of tissue in a more advanced stage from which most of the soft parts had been cut away, furnished the best material for study.

Cross sections showed the bacteria in the intercellular spaces, where they increased rapidly and as soon as sufficient enzyme was elaborated, it softened the middle lamella and permitted the bacteria to penetrate between the cells. These enzymes had a marked action on the cell-wall, which gradually swelled up and lost all trace of its striated character. The cell wall at this stage also lost very largely its faculty of taking up the stain, and sections stained with carbol fuchsin showed the enormously thickened cell-wall, faintly stained a pale pink, while adjacent healthy cell-walls were deep red in color and showed very plainly the middle lamella and striations.

The figures 9-10 show the different stages in the destruction of the cells by this bacillus. Fig. 9 shows the bacteria in some numbers in the intercellular spaces, some are just beginning to penetrate along the middle lamella At this period, the cell-wall is stained deeply. The last stage, just before the absolute collapse of the tissues, may be seen in Fig. 10, in which the lumen of the cells is very small due to the enlarging and softening of the cell-walls which now stain even more faintly than before. The bacteria have also enormously increased.

Sections of pieces of turnips affected with the rot, showed slightly different features; although the action of the bacillus was the same.

Turnips cells have much thinner walls than the cauliflower petiole, or stem ; consequently, when attacked with rot they collapse more rapidly, and the marked swelling which we see in the cauliflower is either absent or less well developed.

Fig. 11 shows the bacteria in the intercellular spaces, the slight swelling of the cell walls and the beginning of the disorganization of the cells.

## Inoculation Experiments.

It was found impossible to perform trustworthy inoculation experiments with plants grown in the field, as in this locality the white turnips and cauliflowers were more or less affected with the rot, hence it was necessary to grow fresh plants, from clean seed, in soil which had never been used for growing these plants. On account of the lateness of the season, the plants were grown under glass and all the following experiments, unless otherwise stated were conducted on pot-grown plants in a greenhouse with an average day temperature of 20-25° C.

### *Series 1.*

Three plants each, of cabbage, cauliflower, rape, white turnip, swede turnip and kale were inoculated with needle punctures through the parenchyma of the leaves. The platinum needle was dipped into a twenty-four hour bouillon culture of the organism, and from three to five punctures were made on one or two leaves of each plant.
Results :—

*Cabbage.* In two days, the inoculated leaves were flaccid and whitish brown in the vicinity of the punctures. This area increased slowly for five days and then dried out.

*Cauliflower.* In two day, there was a flaccid, papery area surrounding the punctures; in five days, all leaves were rotted and had dropped down parallel with the stem of the plant.

There was no subsequent infection of the stems; the leaves gradually dried off at the base of their petioles.

*Rape.* No results followed inoculation.

*White Turnip.* Slight infection was produced around the punctures; but the lack of moisture seemed to hinder further growth.

*Swede Turnip.* No results followed the inoculation.

*Kale.* No results followed the inoculation.

*Control Plants* of each species, pricked with a sterilized needle remained perfectly healthy.

This series, therefore, showed that the inoculation of the germ made with needle pricks in the parenchyma of the leaves, produced more or less disease in cauliflower, cabbage and white turnips. The absence of sufficient moisture in the greenhouse, however, prevented the disease from becoming thoroughly established.

*Series II.*

This series was a duplicate of Series 1, only an agar culture of the organism was used instead of a bouillon culture.

The results were similar to those in series 1, with the exception of the Swedes, which became slightly infected. In one plant, a whole leaf rotted and fell off the plant; but the petiole subsequently dried off.

*Series III.*

In this series, three plants each of cabbage, cauliflower, rape, white turnip, Swede turnip and kale, were inoculated with needle punctures through the veins of the leaves. The needle was dipped in a 24 hour old bouillon culture, and from 3 to 7 punctures were made on one or two leaves of each plant.

Control plants were punctured in the same manner; but with a sterilized needle.

RESULTS :—

*Cabbage.* In two plants there was no apparent change; in the other plant a small cavity 15 m.m. long and 5 m.m. wide had been formed on the mid-rib by the rotting of the cells; but this subsequently dried out and the leaf remained healthy.

*Cauliflower.* No results followed the punctures of the veins and mid-rib.

*Rape.* In ten days, the leaves of all three plants were slightly affected, the vein was split, and a watery exudation was present on the surface. The inoculated leaves began to droop; but the disease progressed no further, and the wound became callused and partly healed.

*White Turnip.* The inoculated leaves behaved in exactly the same manner as the inoculated rape leaves.

*Swede Turnips.* No results followed the punctures of veins and mid-rib.

*Kale.* No results followed the punctures of veins and mid-rib.

This series, as a whole, gave less harmful results than the inoculation of the parenchyma. In cabbage, rape, and white turnip some slight disease symptoms were produced; but there was no general infection of the plant. Lack of moisture seemed again to prevent the rapid development of the disease and perhaps the different composition of the vascular cells hindered the formation of cell-destroying enzymes.

*Series IV.*

In this series, three plants of each of the five species already mentioned were used. A small portion of the epidermis on the upper part of the base of a leaf-stalk was removed and two loopfuls of a bouillon culture were rubbed on the exposed portion.

RESULTS:—

*Cabbage.* The leaf-stalk rotted through in three days and the leaf fell off from its own weight. The rotting did not effect the stem, as the diseased tissue dried out.

*Cauliflower.* There was slight rotting, or softening, in two days, and in five days the leaf rotted off, and the portion next to the stem dried up.

*Rape.* Slight rotting occurred for three days, when the wound dried up.

*White Turnip.* In two days, the softening of the tissues at point of inoculation had extended across the petiole. In five days, the leaf fell off, the rotting extending all through the stalk. The infected base then dried and healed.

*Swede Turnip.* Behaved the same way as the white variety.

*Kale.* In three days, the leaves were so much rotted through that its own weight caused it to break off. The wound then dried up.

*Control Plants* with the epidermis removed, but with no inoculation, remained healthy.

In the above account of this series, the results are given for only one plant of each species, the two remaining plants of each lot behaved in a similar manner. These plants showed considerably more disease than those inoculated by vein or parenchyma punctures. This was probably owing to more moisture being present. At the juncture of the stalk with the stem, small drops of water would collect from the leaf surface, thus providing more moisture for the bacteria. As soon as the leaf had rotted off, or fallen by its own weight, no more water collected in the angle of leaf and stem and the tissues rapidly dried up.

*Series V.*

In this series one plant of each of the species already mentioned, was used.

The lowest leaf of each plant was cut off, about an inch from its juncture with the stem. The cut surface was then rubbed over with a platinum loop, charged from a bouillon culture of the organism. Check plants received the same treatment, without inoculation. The results were very similar to Series IV. and need not be repeated in detail. Rotting usually extended downwards toward the stem for about half an inch, or even as far as the juncture with the stem, and then dried ont. The check plants showed no signs of rotting.

*Series VI.*

Three cauliflower plants were inoculated at the base of the petiole with a bouillon culture by means of two or three needle pricks. In two days, there was rotting, the affected area being 3 x 7 m.m. One of these plants was then placed under a bell-jar and at the end of six days the incculated petiole and leaf were completely rotted, the leaf fell off in a mushy mass and the rot spread to the stem, infecting the whole plant.

The flower head, which was well developed and quite white, gradually changed to a brown color and then rotted. The plant was practically destroyed 14 days from infection.

The diseased area in the other two plants (kept in the same state except that no bell-jar covered them) gradually dried out, leaving a small hole caused by the rotting of the tissues.

Subsequently, this experiment was repeated several times with the same results, the plant under the bell-jar rotting leaf by leaf, with final rotting of the flower.

Fig. 2 shows the beginning of the rot, a leaf (the one inoculated) having rotted through at the base of the petiole and fallen off. The stem of the plant, just below the crown, was darkened, due to the softening and discoloration of the tissues and the lower leaves are beginning to wilt, owing to the cutting off of their supply of nourishment. The leaves of the healthy plant, as shown in Fig. 1, are erect and rigid and comparison with the inoculated plant in Fig. 2 shows the different position of the infected leaves which gradually declined until they were at a right angle with the stem and finally fell or broke off at the base of the petiole.

Fig. 3 shows a plant at a later stage. Most of the leaves are affected and the flower has become brown, and a part of it has completely rotted to a pulpy mass.

*Summary.* The experiments made in this series plainly show the relation of a humid atmosphere to the disease. When the air is full of moisture, it affords the best conditions for the rapid growth of the micro-organism on the exterior of the plant and it favors the production of a large amount of cytase-like enzyme which quickly causes the softening and destruction of the tissues.

*Series VII.*

Under field conditions, one frequently noticed that the leaves seemed perfectly healthy; but the flower was affected. This fact seemed to point to the probability that the flower-head might be very susceptible to the disease; or that the organism might be able to penetrate the unbroken epidermis. In order to test these points, three well developed cauliflower plants were infected in the following manner:

No. 1.—Water drops on the leaves were inoculated with a twenty-four hour old bouillon culture.

No. 2.—A small piece of softened tissue, taken from the interior of an affected petiole with a sterilized wire, was laid on the surface of the healthy flower.

No. 3.—A loopful of bacteria taken from the surface of an agar-slope culture 24 hours old, was gently rubbed over a portion of the dry surface of the flower.

Two check plants were well watered with a syringe and kept under the same conditions as the above, viz., in the warm greenhouse, which has a very humid atmosphere, and an average day temperature of 28 degrees to 34 degrees C, and a night temperature some 10 degrees lower.

Results :—

In two days, No. 1 showed slight discoloration of the treated area. In four days, softening commenced; and in 8 days the whole flower was a pulpy mass.

No. 2 behaved in a similar manner, but the discoloration and softening started earlier and the flower was reduced to a pulpy, blackish mass in 6 days from the time of inoculation. Fig. 4 is a photograph of this plant on the fifth day, the whole flower mass having dropped and turned black.

No. 3 showed no signs of disease even after fourteen days.

N. B.—No water was syringed on the flower of this plant.

The check plants were syringed every day and remained absolutely healthy.

*Summary*: These experiments seem to show that, provided sufficient moisture is present on the interior of the flower of the cauliflower, infection by *Bacillus oleraceae* can and does take place. If small portions of the rotted tissues were placed upon the flower of healthy plants, infection took place, in spite of the mechanical resistance of the cuticle and epidermal cells. Many plants, under field conditions, were found with the flower alone infected.

*Series VIII.*

In this series three healthy white turnips (Greystone variety) were inoculated at the crown with two needle punctures. A check plant was treated in a similar manner, but with a sterilized needle.

Nothing was noticeable for two days; but on the third day, a small drop of water was exuding from each puncture of the inoculated plant and on the fifth day, rotting to a depth of 5 m.m. had taken place. In 14 days, the plants were dead, Fig. 8 is a photo of one of these plants 9 days after inoculation.

The check plant remained perfectly sound and healthy.

Subsequently the experiment was repeated, with the same results. Fig. 6 shows the extent of the rotting process, 6 days after inoculating with one needle puncture while Fig. 7 shows the most complete rotting 10 days after inoculation.

The Greystone turnip in all the inoculations was very susceptible to this disease.

*Series IX.*

Three healthy Swede turnips were inoculated at the crown with two needle punctures. A check plant was treated in a similar manner; but the punctures were made with a sterilized needle.

Two days after inoculation, there was a slight softening of about 2 m.m. in diameter around the puncture. In five days the area was only slightly larger and there was no further increase of the disease; although the plants were kept under observation for three weeks.

The check plants remained sound.

Subsequently this experiment was carried out in the tropical house, in a warmer and moister atmosphere. The results of the inoculation were, however, the same as before, a slight local rotting, followed by a gradual drying up of the infected area.

It seems that although the Swede turnip is not wholly immune; yet it has considerable natural immunity from this disease. This is proved partly from the experimental date above presented, and partly from the fact that we found very little disease among Swede turnips growing in the fields; although on our own grounds, some lots of Swede turnips were growing alongside white turnips which were very badly infected with the disease

*Series X.*

In this series, two white turnip plants and two cauliflower plants were watered with about half a litre of water in which a bouillon culture of the *Bacillus oleraceae* had been poured. This watering was again repeated two days later and all the plants, including two check plants, watered without the addition of culture were kept under observation for about five weeks. No disease developed in any of the plants, which seems to indicate that the *Bacillus oleraceae* does not gain entrance to the plants through the root hairs.

One of the turnip plants of this series was subsequently inoculated at the crown and rotting followed in the course of a few days, thus showing that the turnip plant is susceptible to the disease.

*Series XI.—The Virulence of Old Cultures.*

In order to test the pathogenic power of old culture, both a cauliflower and a white turnip were inoculated with an agar culture of the rot bacillus, 2 1-2 months old, being the seventh transfer after isolation.* The cauliflower was inoculated, by means of needle pricks in the leaf, and kept in warm, moist place. In three days the first signs of rotting were noticed and the disease subsequently ran its usual course, ending in the complete destruction of the plant.

The turnip was inoculated with a puncture at the crown, which gave rise to the rotting and final destruction of the plant.

*Summary*: These experiments prove that the bacillus is able to retain its virulence, for a considerable length of time, in artificial agar cultures.

* I have since tried the virulence of cultures which have been on agar for more than 18 months. The cultures produced the characteristic rot in inoculated plants.

## Inoculation of Freshly Gathered Vegetables.

In all the following experiments, the vegetables were obtained fresh from the garden. These vegetables were thoroughly washed in running tap water and then, by means of sterilized cool knife, slices were cut and placed in Petri dishes. These slices were immediately inoculated by rubbing a platinum loop, (which had been charged with a bouillon culture) over their surface. In all cases, uninoculated slices of the different vegetables were also kept in order to check any contamination from germs growing on the surface, or from those which might develop from insufficent care in the preparation of the slices. In no cases did such uninoculated slices decay or rot.

All the cultures were kept at room temperature, which varied from 20-28° C.

*Cauliflower.* The whole plant, after rinsing, was cut down the centre and placed in a large dish, and then inoculated. In two days, the stem and flower had discolored to a dirty brown, and softening extended downwards about 20 m. m. There was a very disagreeable smell. In 7 days, the whole of the plant was completely rotted could be cut down and across with a platinum needle and the dirty brown color was darker. Gas bubbles were present in all the decayed parts,

*Cabbage.* Cabbage plants, treated like the cauliflower, underwent the same change and in 7 days there was a complete softening of the whole plant, with the production of a very bad odour.

*Turnip* (White). In two days a whitish wet growth spread over the surface of the slice. There was a pale brown discoloration of the infected part. The rot extended downwards to a depth of 10 m. m. In 5 days, complete softening had occured. The smell was slightly disagreeable.

*Turnip* (Swede). Decay in the yellow turnip was usually slower than in the white, but depended largely on the amount of moisture present. Where the turnip was very moist, decay advanced rapidly; but on drier surfaces decay was slower, and at times no growth took place.

There was considerable exudation of water on the inoculated part and abundant brown-black growth which softened to a depth of 4 m.m. After two days growth, gas bubbles were present. Frequently, a whitish moist growth was noticed instead of the brownish-black, due either to difference of water content or to difference of variety. Observations were madeon some thirty turnips of several different varieties.

*Rape.* In two days, there was a water soaked appearance, slight smell and slight softening. After 7 days, the slice, 12 m. m. thick, was completely softened, the odour was bad and on the surface a white, moist growth was present.

*Radish.* In 24 hours, the surface was covered with a copious watery exudate. The affected area was darkened and softened to a depth of 6 to 7 m. m. In two days, the radish had completely softened, was blackish in appeance with a thin, dirty white skin on the surface. The pigment of the skin was dissolved and colored the condensation water. In 6 days, the radish was completely dissolved, forming a thick, dark, liquid.

*Parsnip.* In two days, softening to a depth of 10 m. m had occurred. There was considerable water lying in the form of drops on the inoculated portion. The growth on the surface was moist and yellowish white in color and around the growth the parsnip was brownish black. In 7 days, the slice, 12 m. m. thick, was completely softened. There was no smell.

*Carrot.* In two days, there was abundant growth (both on the red and yellow portions of the carrot) which was transparent and very wet, and the carrot had softened to a depth of 4 m. m. The growth on the surface subsequently became whitish, and complete softening occurred in 6 days. The yellow portion of the carrot was somewhat darkened. There was no smell.

*Carrot.* (White). Abundant, whitish green, sputum-like growth, raised and wet. Outside the growth, there was a yellow to yellowish brown discoloration, especially around the vascular ring and softening had occurred to a depth of 5 m. m. In 5 days, the slice was completely softened, and the odor was pungent.

*Mangel.* In two days there was a whitish growth on surface with slight softening. In 7 days, the softening had increased; but not to the same extent as on carrot or parsnip. There was also some discoloration.

*Beet.* No growth and no discoloration.

*Sugar Beet.* In 24 hours, no softening and no growth. In 48 hours, there was a very slight growth on the surface while the softening was scarcely 1 m.m. in depth. In three days, the growth increased, was white and moist; but there was very little, if any increase in softening. No further growth took place even on slices kept for 10 to 20 days.

*Potato.* It grew with great rapidity on raw potato, in the form of a moist, creamy, yellow, spreading growth with marked softening In five days, slices 20 m.m. thick were completely softened and could be cut with a platinum needle. There was a depression in the centre and an ammoniacal smell. Nessler's reagent gave a distinct coloration to the water extract of the inoculated potato, indicating the presence of ammonia. Tincture of iodine did not color the inoculated potato blue, the starch was, therefore, destroyed.

*Celery.* In two days there was a moist whitish growth with yellowish discoloration and considerable softening. In 7 days the softening was more extensive and the discoloration brown.

*Tomato.* (ripe). After two days, there was a slight growth at seat of inoculation. In 7 days there was rotting and cracking of the skin with whitish growth extendiug from the cracks. The inside was quite soft.

*Green Tomato* behaved in the same way, but growth was somewhat quicker. The first indication of the disease was slight discoloration or premature ripening of the inoculated part followed by exudation of water and softening and later by cracking of the skin and progressive softening.

*Artichoke.* (Jerusalem). In 24 hours the surface growth was moist and dirty white in color, and there was softening beneath surface to a depth of about 7 m.m. outside the circle of growth the tuber had become red brown in color. In 48 hours the softening was deeper with pitting of the affected portion. Color around the affected portion became reddish. In 4 days the whole tuber was soft.

*Asparagus.* The upper third portion of the Asparagus stem (the edible part) was the first part to rot, presenting a water-soaked appearance. On the third day after inoculation, the middle third commenced to soften and on the fourth day, the lower third began to do the same. The pieces gradually collapsed and a dirty white skin formed on the surface.

*Horse Radish.* Softening of the tissue, even of the hardest and most woody parts, to a depth of 2 - 4 m.m. occurred in 48 hours. There was a whitish growth on the surface, gas bubbles formed, and the centre of the stem fell in. The odor on the third day was quite pronounced and very objectionable.

*Rhubarb.* The organism grew on the cut surface of rhubarb only when the petiole was well saturated with water. There was a whitish growth on the surface, and softening, especially of the tissues between the bundles. Long, slimy threads, a foot or more long, were drawn out by touching the affected portion with the platinum needle.

*Onion.* On the slices of onion, strongly acid to litmus, there was considerable growth in 24 hours. The tissue was softened and the parts affected were slightly yellow in color. In three days the growth was quite yellow,a few gas bubbles were seen on the surface, the tissues were completely softened and there was a foul, nauseating odor.

Twelve onions, of three different varieties, were inoculated; but all rotted in the manner above described.

*Morphology.* The bacillus varies considerably in length. From agar culture grown at 20°C. for 24 hours the bacilli vary from 1-3$\mu$ in length, the average is about 2$\mu$, the width 0.6$\mu$. In old (3 month) agar cultures the bacteria are shorter. In gelatine (3 days at 20°C.) the average length is 1.4$\mu$ width .5$\mu$. In beef bouillon (48 hours at 25° C.) the average length is 1.2$\mu$ and the average breadth .7$\mu$. In wort (12.2 Ball.) the bacilli are longer, averaging 4$\mu$ long and 1$\mu$ wide. The longer rods are frequently bent and will stain deeper at the poles than at the middle.

On rhubarb the bacilli are short and plump and many are ovoid in shape. They are about 1.1$\mu$ long 0.8$\mu$ wide.

In sections of diseased cabbage and cauliflower the bacilli vary greatly in length, averaging about 2$\mu$ long and 0.6$\mu$ wide.

The ends of the bacillus are always rounded, occasionally bent rods may be seen and short chains may form; but usually the bacillus occurs singly.

*Flagella.* The bacilli taken from agar cultures 24 hours old are very motile, as are also bacilli from other media, (wort, gelatine, cauliflower). The linear progression is fast and the rotary motion of the cell is quite noticeable, the rear end of the motile rod moving in a larger circle than the front.

The bacillus has peritrichous flagella, seven to thirteen in number, which stain well by Van Ermegen's method. (See Fig. 11).

*Spores.* No spores have been observed. *Involution forms* are found. Thus the bacteria may be ovoid, or long and bent, occasionally club-shaped individuals are seen.

*Stains.* The bacillus from gelatine culture stains well with gentian violet, not so well taken from agar. Carbolfuchsin gives good results, for cover glass preparations and also for sections of diseased tissues. It stains slowly with methelene blue. In three minutes the bacilli are only very faintly colored.

It does not accept Gram's Stain.

CULTURAL CHARACTERS.

*Bouillon* at 28° C. In 24 hours the culture was very turbid, no pellicle and heavy sediment. In 48 hours the turbidity increased. The sediment was heavier and flocculent masses were deposited on the sides of the tube. A ring formed at the surface. In three days a pellicle formed which settled on slight disturbances. In six days the pellicle and ring on undisturbed tubes were heavier.

Media remained turbid (4 weeks).

In cabbage bouillon with 1 per cent. of peptone the organism grew very well, and produced heavy turbidity and copious sediment in 24 hours, a slight ring formed at the surface on the fifth day, otherwise there was no change.

*Gelatine.* On plate cultures of nutrient gelatine the colonies were visible to the naked eye in 24 hours. They were punctiform and round. With ⅔ objective they appeared round, homogenous, with weak refraction and entire edges. In 48 hours the surface colonies were 2 m.m. in diameter, liquefying, round, greyish white in color aad with a ring in the centre composed of deposited bacilli. Under the microscope (⅔ obj.) they were round, coarsely granular, the centre was grumose, and the edges slightly ciliate. Deep colonies were considerably smaller, less than 1 m m. in diameter, round, internal structure moruloid, edges of some colonies were entire, others with effused growth. There was considerable variation.

In three days the surface colonies were from 3-5 m. m. in diameter round, greyish color, liquefaction shallow, often with one or two concentric rings. Under the microscope the edges appeared ciliate, the centre moruloid, and the rest of the colony granular. The bacterial masses might be seen in motion.

The deep colonies were smaller with darker centre and ciliate edge, the fringe being longer and more wavy and interwoven than in the surface colonies.

In 4 days the colonies were larger in size otherwise there was no change.

In stich cultures at 20° C. there was a white growth along the line of puncture in 24 hours. Slight liquefaction at the surface, $\frac{1}{2}$ m.m. in diameter, along the line of inoculation the growth was slightly heavier. In 4 days the liquefied area reached the sides of the test tube and thereafter liquefaction was stratiform.

There was often considerable difference in the rate of liquefaction, at times the whole tube might become liquefied, at other times only the half.

*Wort gelatine.* Stich cultures. The organism grew very well in this medium, with shallow pit liquefaction, followed by stratiform liquefaction to a depth of 5 m.m. in 7 days (20° C.) Growth stopped when about half the medium was liquefied.

*Whey gelatine stich cultures.* There was a crateriform depression 12 m.m. in diameter, with deposition of a flocculent mass in the centre of the pit in 24 hours. In 48 hours liquefaction had extended to the sides of the tubes and downwards to a depth of 2 m.m. at the sides and 3 m.m. in the centre. In three days the liquefied portion was 5 m.m. deep and growth ceased when 9 m.m. deep. A few gas bubbles appeared in the gelatine at some distance from the line of puncture

*Agar.* On agar plates at 28° C. colonies were not characteristic. Surface colonies spread very fast, as thin grey expansions, which varied greatly in shape. Deep colonies were dense, punctiform, round, or elliptical; in fact, there seemed every variety of shape Agar slope cultures at 28° grew very rapidly over the surface as a moist, thin, whitish growth, slightly opalescent by transmitted light. There was considerable deposit of the bacilli in the condensation water. The growth became more massive with age, otherwise there was no change.

*Carbo-hydrate agars.* Slope and shake cultures were made in agars containing 2% of the following carbo-hydrates: Glycerine, saccharose, lactose, glucose, and maltose. The media was made from Liebig's Extract of Meat, reaction neutral. Check cultures were made in agar without carbohydrates, no gas formed in these.

In glycerine agar the growth was more abundant and whiter than on plain agar. No gas in the shake culture and heaviest growth on the surface.

In saccharose agar amount of growth exceeded that on plain agar. In shake culture a few gas bubbles were present.

In lactose agar the growth exceeded that on plain and glucose agar and was more waxy looking. In shake cultures there were numerous lenticular gas bubbles. In 48 hours there was an increase in the number of gas bubbles, and the agar was rent across the tube. In three days the clear space between the rents was wider, otherwise no change.

In glucose agar the growth was about the same as on plain agar, if anything, slightly heavier. Shake cultures contained small gas bubbles all through agar. No further change after three days growth

In maltose agar growth was very abundant, moist and shiny. There was more tendency to spread. Growth exceeded that on plain agar.

In shake cultures very few gas bubbles appeared in 24 hours. In 48 hours, a few more bubbles made their appearance and no further change took place after the third day.

*Neutral red agar* (with 2 per cent. glucose at 28° C.) In 24 hours, there was no change in color, a white growth along the line of puncture and a moist white growth on the surface. A few gas bubbles were present. In 48 hours, there was no change in color but more growth. On the sixth day, the color was lilac violet and no further change occurred. (20 days.)

*Milk.* A number of milk tubes + 1.5 per cent., inoculated with 1 oese of a fresh bouillon culture and held at 25° C shewed no change for 24 hours. In two days the milk was thicker but did not coagulate until the third day. The curd was soft and even, but thicker at the bottom of the tube. On the fourth day, the curd shrunk and on shaking, the whey separated out. The curd was flaky with a few gas bubbles in it. On the fifth day, the whey on the surface was clear and remained so. In eight days, the curd shrunk and occupied one-third the depth of the medium. No further change took place. The whey from milk cultures tested for proteolytic enzymes, by means of the caustic potash and copper sulphate test, gave a violet color indicating the presence of peptones. Another portion of whey was mixed with ammonium sulphate to precipitate the proteids, and the filtrate from this precipitate was also tested in the same way, and with the same results.

The odour of milk cultures after heating was agreeable, resembling cheese curd. No odour could be noticed in the cold cultures.

The viability of the organism in milk was as follows: Cultures, 25 days old, living; 35 days old, living; two months old, dead.

*Litmus Milk* at 25° C. In 24 hours the color compared with the control tubes was appreciably different. In 48 hours, the color was lighter, between lilac and livid (Saccardo 48 and 49), the milk was thick but not coagulated. In three days, the milk coagulated into a soft even curd with about 10 m. m. of whey on the surface and a few gas bubbles in the coagulum. Colour lilac (Saccardo 48). In four days, the curd had shrunk leaving a clear whey on the surface. The curd when shaken separated into flaky masses and gas bubbles were fairly numerous through the curd on the surface. The color of the curd at the bottom of the tube was white, the upper portion, lilac. On the fifth day, the whey was slightly tinged with color; the lower half of the curd was white and the upper half, lilac. On the eighth day, there was only a small red ring of color at the top of the curd. On the twelfth day, the lilac color again returned.

*Blood Serum* at 25° C. On blood serum good growth occurred,—first, as a moist slightly spreading growth, later becoming heavier, more opaque and opalescent by transmitted light, The condensation water was turbid. Slight liquefaction was visible on the 8th day, and in 21 days most of the sloped surface became liquid and no further change occurred. The bacilli from blood serum shewed banded and bipolar staining with carbol-fuchsin.

*Egg Media.* (Dorset's method). Good growth occurred on egg media, spreading over the entire surface. No liquefaction occurred in 24 days and the growth was not characteristic.

*Dunham's Solution* at 25° C. In Dunham's solution there was slight growth; and uniform turbidity in 24 hours, the cloudiness increased and a slight sediment formed which became flocculent in four days. Eight-day cultures gave a very slight indol re-action, while in 15-day cultures the re-action was more marked.

In Dunham's solution with Rosolic acid (in the same proportion as used by Jones), the salmon pink colour almost entirely faded in 24 hours. In 48 hours, the tubes were quite decolorised and remained so three months. Rosolic acid bouillon was decolorised in the same way. This change shewed the formation of acid.

*Synthetic Media.* In Uschinsky's medium there was turbidity with some sediment in 24 hours at 25°C. A slight pellicle formed in 48 hours, and the body of the media became more turbid with increase of sediment. In seven days there was a thick pellicle and heavy sediment, but the body of the liquid was almost clear. In 15 days the pellicle gradually sank, the body of the liquid was pale yellow, and there was a copious sediment.

In Fermi's medium, there was slight turbidity in the upper third of the medium and a very slight sediment in 24 hours at 25°C. A thin pellicle formed in 48 hours and the top of the liquid was very cloudy. On shaking, the pellicle produced turbidity throughout the entire medium. The growth at four, seven and fifteen days resembled growth in Uschinsky's medium.

In *Lager Beer Wort,* 12.2 Ball. good growth occured, at first turbid and with considerable sediment. The liquid was several shades lighter in color, and a few gas bubbles were seen. In three days, the wort was quite clear, with heavy fine sediment and no pellicle. No further change occurred.

*Cooked Vegetables.* Generally speaking, the growth on cooked vegetables was abundant, but the softening action of the organism on the cooked vegetables was not always as marked as its action on raw vegetables ; in other words the production of cystase was more marked when the organism was placed upon slices of raw vegetables.

*Potato* prepared according to Roux's method, reaction slightly acid to litmus. In 24 hours there was a moist, shiny, spreading growth distinguishable from the potato by the glistening appearance. The growth became more massive and on the drier slices the growth was more waxy looking and straw colored. No further change occurred and the potato slice was slightly softened, it could never be cut quite through with the platinum needle.

On potato cylinders prepared by immersing half the slice in water, the growth was moist and spreading. The water was at first turbid with much sediment, consisting of particles of softened potato, pure white in colour. In seven days the liquid became yellow in colour and the sediment was pure white. Gas bubbles were also present.

The immersed portion of the cylinder was softened, but in twenty days the core above the water was still firm and could not be cut with the platinum wire, a control test on raw potatoes from the same source caused complete softening of the tissues in three days.

In other tests of potatoes there were minor differences—Thus the growth would be dirty yellow, or honey yellow in colour, and the moist and glistening appearance on some potatoes would be changed to a dull waxy looking growth.

Differences in the rate and extent of softening also occurred. In all some 60 tests were made on potatoes.

On cooked carrot at 28°C, there was a moist spreading growth with complete softening in three days.

On cooked sugar beet there was a flat, shiny, moist growth; gas bubbles were present, and the cylinder was completely softened in four days.

On cooked beet-root there was a whitish spreading growth, the beet was discoloured (brown-green), and there was a white, slightly raised moist growth, with complete softening.

On cooked onion there was a moist, dirty white growth, the onion was completely softened and fell to pieces. The odor was foul and nauseating.

*Temperature relations.* The optimum was about 30° C.; there was fast growth at 25° to 28°. Good growth occurred at 20° and at 37.5° C. the growth was better than at 20° C.

The maximum temperature was in the neighborhood of 42° C.

Tne minimum temperature was in the neighborhood of 5° C.

*Thermal death point.* The thermal death point was determined by Sternberg's method. The temperature of the bath during the time of exposure was varied about .25 of a degree. A temperature of 55° C. for 10 minutes was the thermal death point of the organism.

*Relation to free oxygen.* The aerobic growth was better than the anaerobic, but the organism grew in the closed arm of fermentation tubes, and in deep stich cultures.

Agar, potato, gelatine slope and litmus milk cultures were grown for eight days in a Novy jar in an atmosphere of hydrogen.

There was slight growth limited to the needle track on the agar slope; slight growth but no liquefaction of the gelatine slope culture; very slight growth on the potato; slight growth and change of colour in milk, but no coagulation. The cultures when taken out of the Novy jar grew vigorously. The bacilli from the agar culture were rather shorter, averaging about 1.5$\mu$, in length.

*Nitrate broth* at 25° C. In nitrate broth growth was better than in Dunham's solution. The media becomes turbid with first a fine and later a flocculent sediment. No pellicle formed.

The tests for nitrites on the 9th day were negative, on the fifteenth day there was a faint pink tinge with the napthylamine and sulphanilic acid test. Control tubes kept under the same conditions gave no indication of nitrites.

*Indol production.* See Dunham's solution.

*Development of odors.* The strongest and most offensive odor developed on onions, both raw and cooked. There were objectionable odors from cultures on cabbage, cauliflower, horse radish, rape and turnips.

The odor on white carrot was pungent. Milk cultures when heated give an odor of fresh curd.

*Production of hydrogen sulphide.* Strips of filter paper moistened with lead acetate were suspended over bouillon and potato cultures. In both cases the paper turned black indicating the production of hydrogen sulphide.

*Production of acid.* Acid was produced in all sugar media, in milk, in Dunham's solution, and in bouillon.

*Production of alkali.* Ammonia was produced in potato cultures in considerable amount, it could be detected by the smell, as well as more exactly by Nessler's reagent. Cultures on several other vegetables (turnips, carrots, beets) also gave the Nessler reaction.

*Relation of growth to acid and alkali.* Various quantities of normal soduim hydrate and normal hyrochloric acid were added to neutral broth. The following results were from 48-hour old cultures kept at 28° C.

Neutral broth. Turbid and considerable sediment.

| | | | | | |
|---|---|---|---|---|---|
| Alkaline | broth | + 10c.c. | of normal | NaOH per litre: | Same as neutral tubes |
| “ | “ | “ | “ | “ | “ “ |
| “ | “ | 20 | “ | “ | “ “ |
| “ | “ | 30 | “ | “ | Turbid and slight sediment. |
| “ | “ | 40 | “ | “ | Very slight turbidity. |
| “ | “ | 50 | “ | “ | Quite clear, no growth. |
| Acid | broth | + 10 c.c. | of normal | HCl per litre: | Turbidity greater than in control. |
| “ | “ | 20 | “ | “ | Same as neutral tubes. |
| “ | “ | 30 | “ | “ | Slight turbidity. |
| “ | “ | 40 | “ | “ | “ “ |
| “ | “ | 50 | “ | “ | Very slight growth. |

*Effect of sunlight.* Cover glass preparation made from 24-hour old bouillon culture and exposed to direct sunlight gave the following results:—

| | | | | |
|---|---|---|---|---|
| 15 minutes | + + | ............... | 30 minutes | + + |
| 45 " | + + | ............... | 1 hour | + — |
| 1.15 hours | + — | ............... | 1.30 hours | — — |
| 1.45 " | — — | ............... | 2 " | — — + |

$\pm$ Living on some cover glasses but dead on others; + living; — dead.

Agar plates inoculated with 1 oese of a fresh bouillon culture and exposed to direct sunlight gave the following results:

Control plates not exposed 1,200-2,000 colonies per plate.

| | | |
|---|---|---|
| Plates exposed 15 minutes | centre, 2-5 | colonies per plate. |
| | edge, 220-400 | " " |
| " " 30 " | centre, 0-10 | " " |
| | edge, 130-200 | " " |
| " " 45 " | centre, 0-1 | " " |
| | edge, 10-60 | " " |
| " " 1 hour | centre, 0 | " " |
| | edge, 10-60 | " " |
| " " 1.30 hours | 0 | " " |
| " " 2 " | 0 | " " |

The plates were exposed in the afternoon between 2 and 4 p.m. in the month of October. Temperature of the plates, 30° C. Latitude, 43°, 30."

*Resistance of the organism to desiccation.* For determining the resistence to dessication cover glass preparations were made from a 24-hour old bouillon culture and exposed to the light in a room for various periods of time. Under these conditions the bacillus was killed after two days exposure.

*Growth in Fermentation Tubes.* The foundation medium was composed of 1 per cent. peptone, .25 per cent. Nahrstoff Heyden, and 5 per cent. salt, with the reaction carefully neutralised to phenolphtalein, 2 per cent, of the following sugars, saccharose, lactose, glucose was added to the above medium, and the tubes sterilized at 100° C. on three successive days.

*Saccharose bouillon.* Both arms of the tube became cloudy, considerable sediment formed but no pellicle. Reaction after 10 day's growth + 1.8 per cent.

*Lactose bouillon.* After 24 hours both arms of the tube became cloudy, the closed one with less turbidity, there was some sediment but no pellicle or gas. After 48 hours, the amount of sediment increased and 1 per cent. of gas formed, subsequently the closed arm became clear, but there was no increase of gas. Reaction after 10 day's growth, + 1.43 per cent.

*Glucose bouillon.* There was more growth in this medium than in the others, 0.5 per cent. of gas collected on the 2nd day, with no subsequent increase. Sediment very copious. Reaction after 10 day's growth, + 1. 8 per cent.

*Enzymes.* Proteolytic enzymes, cytase, and diastase are produced by the organism. Evidence as to the formation of these enzymes is afforded by the following experiments.

*Proteolytic Enzymes.* These enzymes are produced in small quantities. Gelatin is slowly liquefied, blood serum even more slowly, milk is partially peptonized.

Fresh milk serum sterilized by filtration was inoculated with a culture of the bacillus, and the medium held at 25 degrees C., for 10 days. At the end of this time a portion tested for peptones gave the biuret reaction. The proteid bodies except peptones in the larger portions were precipitated with ammonium sulphate and the filtrate treated with caustic potash solution and copper sulphate gave a violet color indicating the presence of peptones.

*Diastase.* Diastase is produced in small quantities in ordinary bouillon. Equal parts of sugar free starch paste and thymol were mixed with a 10-days old bouillon culture and left at 25 degree C., for 12-24 hours. A test of the filtrate of this mixture with Fehling's solution showed small traces of sugar to be present.

The organism when grown on potato also destroyed starch. Slices of raw potato inoculated with the organism did not give any coloration when treated with iodine, which indicated the destruction of the starch.

*Cytase.* The greatest interest in this organism is its power of destroying the cell walls of various plants. The quick spreading nature of the rot shows that the cell-wall-destroying-enzyme must be elaborated in considerable amounts.

This enzyme was isolated in the following manner:—

Sound potatoes were peeled and pieces cut out of the centre with sterilized knives. These pieces were scorched over the naked flame of a Bunsen burner and then dropped into wide mouth sterilized flasks containing 50-200 c. c. of sterilized distilled water.

This operation, although carefully carried out in a chamber washed with corrosive sublimate, was not always successful as a number of the flasks became contaminated with foreign organism: however, some flasks were obtained which contained nothing but *B. oleraceae*, and these, after incubation at 25 degree C. for 10 days, were emptied into a fine sterilized cloth and the juice pressed out.

This juice was then filtered through absorbent cotton and treated with four times its bulk of 94 per cent. alcohol, which gave a fine cloudy precipitate. The mixture was frequently shaken and was left at room temperature for 24 hours. After the final shaking the precipitate was allowed to sediment for 12 hours when the supernatant liquid was siphoned off, and the sediment collected on a hard filter paper. washed with alcohol, dried and then a hole was made in the filter and the precipitate washed off into a sterile flask with sterilized distilled water. This solution was then forced through a Pasteur-Chamberland filter, collected in a sterile flask and 5 c. c. portions of the liquid filled into sterilized test tubes. The liquid was clear with a yellowish tinge and was quite sterile. (Incubation of tubes at 25° C.)

Twenty test tubes were thus obtained and 8 of them were treated as follows:—

4 were heated to a temperature of 65 degrees C. for 10 minutes.

4 were heated to a temperature of 212 degrees C. and then cooled.

Small slices of potato and white turnip were then cut with sterile knives and introduced into the tubes which were placed in a thermostat at 20 degrees C. At the end of 24-36 hours the tubes were carefully examined and those that showed bacterial contamination were put aside. The small pieces of tissue were fished out with a sterile spatula and placed on a slide, a cover glass placed on top and the preparation examined under microscope. The sections of turnips and potato in the boiled and heated tubes were unchanged, they were firm, the cell walls unaltered with sharp outlines, and about 2 3-5$\mu$ in width, The tissues in the unheated tubes were very soft, much swollen, and in some cases quite disintegrated. The cell walls were much enlarged, some striated and from 5 8$\mu$ in thickness.

This experiment shows that *B. oleraceae*, secretes a cytase which has a very powerful action on the cell wall and particularly on the middle lamella, and that this enzyme is killed by a temperature of 65 degrees C. for 10 minutes.

## Conditions Affecting the Spread of the Disease.

1. *Metereological Conditions.* The weather of July, August, and part of September was very favourable for the growth and spread of both fungus and bacterial diseases. In Ontario, the rust on cereal crops was very bad. Many newspapers spoke of the grain "being blasted in a single night."

The Toronto Metereological Register shows that July and August, 1901, were warmer and rather moister than the average; in the month of August when the cauliflower diseases was noticed, the average humidity was 86, and the rainfall 3.67 inches. The temperature also was high. Very many mornings in July and August, the dew was so heavy that, in spite of great heat and cloudless sky, one could get quite wet when walking through the rows of cauliflowers in the afternoon. An examination of these plants in the field showed that the base of the plant, or the juncture of the petioles of the leaves with the stem, contained considerable water and in most cases particles of soil and if the organism exists in the soil, which is probably the case, it would be in a favourable situation to cause infection.

The warm weather, combined with excessive moisture, both of the soil and the exterior of the plant, and the fact that transpiration would be checked by this condition, and consequently the plant-cells themselves would be full of sap, undoubtedly played an important part in the spread of the rot amongst the cauliflowers and turnips. In short, we can state that the atmospheric conditions were ideal for vigorous bacterial growth, and that these metereological conditions have considerable influence on the ease with which the bacillus penetrates the plant.

2. *Rankness of Growth.* The weather conditions above mentioned, and the plentiful use of manure by market gardeners, favor very quick, rank growth. The plants most affected were large, heavy, and

with many leaves shading the surrounding soil, thus conserving moisture and promoting quick growth.

3. *Abundance of Insect Pests.* The disease is chiefly spread by means of infection from wounds, and under field conditions these are usually produced by insects, especially the cabbage worm (*Pieris brassicae*) which was very numerous upon cabbage and cauliflower leaves. A careful examination of over 100 plants showed that one or more larvae were present on each plant. Slugs also do considerable damage to these plants, and obviously smear themselves with a number of soil organisms, and as I have already mentioned, the *Bacillus olearaceae* is probably a soil organism.

Ants and other insects swarm around turnips, eating the rotted pulp, and no doubt serve to carry the germs to other plants.

4. *Injury from Planting, Cultivation or Wind.* Leaves of turnips are frequently bruised or injured during cultivation, by either hand or horse hoes. Cauliflowers may be injured during planting out, and the infecting organism brought into contact with the broken surface. In cases of very rank growth, a heavy wind may cause leaves to be broken off, and thus afford bacteria a chance to penetrate into the plant tissues. Many gardeners trim their cauliflowers on the field, and when these are infected they carry the disease on to another season. The same ground is often used year after year for the same crops, a dangerous procedure when disease is present, as it is likely to make the trouble endemic.

5. *Susceptibility of Varieties.* According to the limitations placed upon the meaning of "resistance" and "immunity" in plants by Russell, we shall define resistance as the "inherent power of the vegetable organism to withstand the action of bacteria in general;" and immunity as "the ability of the organism to repel the attacks of a germ which produces a pathological condition in a closely allied form."

We find that white turnips and cauliflowers are very susceptible to inculations of *Bacillus oleraceae,* whether carried out in the laboratory, or met with under field conditions. Our laboratory experiments were all carried out on the Greystone variety of white turnips, which, under field conditions, seems to have some immunity; but which readily succumbs to artificial inoculations. We have kept careful record of the amount of disease present among the different varieties tested on our trial grounds.

Bacteriological examination of the disease present in the different varieties showed that we were working with the same bacterial disease. The amount of disease present is shown in the following list of varieties :—

*Immune* : Jersey Navel.

*Less than 5 per cent. Rotted* : Greystone Improved, Purple Top Mammoth, Early American Purple Top, Red Top Strap Leaf, White Flat Dutch Strap Leaf, White Egg, White Lily, Warly La Crosse, Red Top White Globe, Rennie's Selected White Globe, White Top Strap Leaf, Hunter's Purple Top Globe.

*Between 5 and 15 per cent. Rotted*: White Stone, Cow Horn, Yellow Stone, Green Barrel, Lutton's Imperial Green Globe, White Six Weeks, Milk Globe, Orange Sweet, Long Tankard, Sutton's Favorite P. T. Yellow Hybrid, Sutton's Perfection Green Top Hybrid, Yellow Finland, Large White Norfolk, Sutton's Purple Top Scotch.

*Between 15 and 30 per cent. Rotted*: Early Purple Top Murrich, Pomeranian White Globe, Red Globe Norfolk, Purple Top Hybrid, Jersey Lily, Early White Model, Extra Early Milan.

*Between 30 and 50 per cent. Rotted*: Orange Jelly, Imperial Green Globe, All Gold, Yellow Globe.

*Between 50 and 65 per cent, Rotted*: Yellow Aberdeen Green Top, Yellow Aberdeen Purple Top.

Fig. 1. A healthy cauliflower plant; uninoculated and grown under the same conditions as the inoculated plants.

Fig. 2, Cauliflower plant inoculated from a pure culture of *B.oleraceae* by means of a single needle prick at the base of the petiole. At the end of six days. Note the fallen leaf, wilted appearance of the leaves on the left side and the blackened stem above the fallen leaf.

Fig. 3. Cauliflower plant inoculated from a pure culture of *B.oleraceae* by means of a single needle prick at the base of a petiole. Shows the rotting of the flower. Ten days from inoculation.

Fig. 4. Cauliflower plant inoculated by placing a piece of softened tissue, taken from the interior of an affected inoculated petiole, on the surface of the healthy flower. The flower is reduced to a pulpy, black mass. Five days from time of inoculation.

Fig. 5. A white turnip plant inoculated at the crown from a pure culture of *B. oleraceae* by means of two needle punctures. The photograph shows the plant nine days after inoculation.

Fig. 6. A turnip plant cut in half in order to show the extent of the rotting process, six days after inoculation with *B. oleraceae* by one needle puncture.

Fig. 7. A turnip plant cut in two in order to show the almost complete rotting. Ten days after inoculation with *B. oleraceae*, one needle puncture at the crown.

Fig. 8. The edible portion of a cauliflower cut in two with a sterilized knife and inoculated with a pure culture of *B. oleraceae* by means of a single needle prick in the centre of the flower. Note the blackened portion which was softened to a considerable depth and also the water drops upon the blackened area.

Fig. 9. Cross section of part of the petiole of a diseased cauliflower inoculated with a pure culture of *B. oleraceae*. Note the bacteria in the intercellular spaces and their penetration along the middle lamella.

Fig. 10. Cross section of the petiole of a cauliflower plant inoculated with a pure culture of *B. oleraceae*. At a later stage than Fig. 9, showing the almost complete collapse of the tissues, the enlarging and softening of the cell walls and the great increase in the number of bacteria.

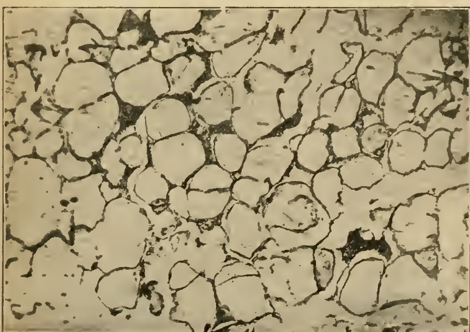

Fig. 11. Cross section of a piece of turnip. This was taken from a plant inoculated with a pure culture of *B.oleraceae*. Note the disorganization of the cells and the large numbers of bacteria in the intercellular spaces.

Fig. 12. *B.oleraceae*. The flagella stained by Van Ermegen's method. The bacteria were taken from an agar culture 18 hours old.

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BULLETIN 138

# The Composition of Ontario Feeding Stuffs.



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Lecturer in Chemistry.

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# THE COMPOSITION OF ONTARIO FEEDING--STUFFS.

By W. P. GAMBLE, B.S.A., Lecturer in Chemistry.

The animal body is made up mainly of four classes of substances—water, ash or mineral matter, nitrogenous matter, and fat. The proportions in which these four classes of substances occur depend mainly upon the age of the animal, its treatment, and the purpose for which it is kept. The components of the body are continually breaking down and being consumed. To keep the animal in a healthy condition there must be a constant supply of new material. If this is lacking or insufficient, hunger and finally death result. To keep up this supply is one of the chief uses of food, but in addition to this, the food supplies the heat of the body, and at the same time furnishes energy, which enables the animal to move the muscles and do work external and internal. Furthermore, foods also supply immature animal with material wherewith to build up the tissues of the body.

It will, therefore, be seen that to supply food in the right proportion to meet the requirements of the animal, without a waste of food nutrients, constitutes scientific feeding, and it is by carefully studying the composition of feeding stuffs and the requirements of animals that a great deal of information may be obtained which will be of inestimable value to the practical agriculturist.

Realizing the importance of such a study, the author of this bulletin wrote to all the proprietors of flour, oat, pea, and starch mills in the Province, requesting them to send us samples of their by-products. Besides the sample obtained in this way we collected a large number of similar by-products from other sources. These feeding-stuffs were carefully analysed, and the tabulated results will appear in their proper places.

Before we examine the results of our analyses, however, let us understand the meaning of the terms used by chemists to designate the various components of a fodder.

(1). Protein (nitrogenous material) is the name commonly given to a class of substances which furnish the materials for the building up of lean flesh, blood, skin, muscles, brain, nerve, hair, horn, wool, etc., and for these purposes protein is absolutely essential in the food of animals. The animal cannot grow, nor can it long exist without constantly renewed supplies of protein in its food. Moreover, the animal is totally unable to create protein. It is true that animals can produce blood protein, brain protein, flesh protein, and milk protein, but only by appropriating and transforming the protein of plants. Protein in some form is an essential constituent of all food.

(2). Fat (or ether extract) is the portion of the food which is dissolved from the water-free substance by ether, benzine, gasoline, etc. It is a very important component of feeding stuffs on account of its high value for the production of fat, energy, and heat.

(3). Crude fibre is a term applied to a group of substances that are of limited value to the feeder, because not only are they largely indigestible, but what is still more important, they often render the rest of the food less digestible by protecting it from the action of digestive fluids.

(4). Ash is the inorganic portion of feeding stuffs. Some of the foods richest in protein are also rich in ash material, and are, therefore, of high manurial value. The ash is also of great importance in the food of young and growing animals, as it furnishes the constituents from which the bone is built up.

(5). Soluble carbohydrates (or nitrogen-free-extract) is that portion of the food which is dissolved by boiling it with dilute acids and alkalies. It consists mainly of starches and sugars. When taken into the system nitrogen-free-extract forms fat or is oxidized to produce heat and energy.

(6). Moisture. However dry a feeding stuff may appear, it always contains a considerable amount of moisture which can be driven out by heat. A high water content in a concentrated feeding-stuff is a decided detriment: first, because it diminishes the percentage of actual food material, and, second, because it causes the food to mould or turn sour sooner than if less moisture were present.

In addition to the chemical analysis, the samples that we collected were subjected to careful microscopic examination, so far as time permitted. The chemical analysis alone gives valuable information as to the total quantities of important food materials contained in the feeding stuff. But as will be noticed in the following tables, certain by-products vary considerably in composition, according to the character of the season, methods of manufacture, etc., and unless they are decidedly abnormal in composition, it is impossible to say with any certainty whether they have been adulterated or not. Since, however, foreign material can be readily shown under the microscope, the combined chemical and microscopic examination is almost certain to detect any adulteration. It is gratiying to know, on account of the importance and wide use made of these materials, that the quality of the samples in most cases examined has been found to be quite up to the average. The only adulterants we were able to detect were particles of flour, whole wheat screenings, and oat bran, which under the conditions of manufacture might be expected to be present.

The tables which we are about to examine show how great are the differences in composition between different kinds of feeding-stuffs. Take, for example, the percentage of protein in cotton seed meal and compare it with that in corn bran, or even with that of some of the oat feeds. The cotton seed meal, as will be shown, is a very concentrated food, while the amount of protein in corn, bran, and such substances is very low. Protein is the most expensive component of a feeding stuff and as has been stated, a considerable amount of it is absolutely indispensibie to growth.

Hay, ensilage, corn, and roots, raised on the farm form the basis, and make up the bulk of the food for live stock, and supply all the starch, sugars, and fat required. They are, however, deficient in digestible protein, and if the quantity of digestible protein in a food is too small the animals produce less beef or milk than they would with a proper supply of protein. Furthermore, when protein is deficient the other food components (starch, fat, etc.) of the ration are in excess of the animal's capacity for assimilating them, and are, therefore, to some extent wasted. These, in part, pass out of the body, incompletely digested, and, unlike protein, give little value to the manure. In purchasing by-products or commercial feeds to supplement farm-grown crops, the keepers of live stock should bear in mind that the value of the food depends to a large extent on the quantity of digestible protein which it contains.

The tables referred to will aid in the selection of food of highest nutritive value. It must be remembered, however, that the tables give the total amounts of nutrients found by chemical analysis in the different feeding-stuffs, while only that portion of the food which is digested is of direct use to the animal.

The processes of digestion in the case of ruminant animals are carried on somewhat as follows: The food is taken into the mouth, where it is masticated and mixed with saliva, a secretion of the glands of the mouth. The saliva acts feebly upon the starch of the food converting portions of it to sugar. The masticated food then passes through the gullet to the stomach, where it is subjected to the action of the gastric juice. From the stomach the undigested food passes through the pyloric orifice into the intestines, where it is further acted upon by the pancreatic secretion, and portions of the starch, protein, and other components of the food are dissolved or emulsified. The dissolved nutrients are absorbed from the alimentary canal, and, in the form of chyle, pass into the blood, and finally serve to nourish and sustain the body. This portion is said to be digested and assimilated, and from it alone the animal is nourished.

The digestibility of different foods, however, varies markedly; and, moreover, the digestibility of the same food varies under different conditions. But under average conditions the digestibilty of the commoner foods has been roughly determined, and the practical feeder must make a study of such data before the figures giving the composition of different foods can be of much use to him. He should also investigate the whole question of digestibility in an independent manner, so as to be prepared to judge wisely in any given case.

We give the results of our analysis, with brief comment thereon :

| FOODS ANALYZED. | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Pea Meal.* | | | | | | |
| 1. Pea meal from solid peas— | 27.13 | 6.17 | 2.11 | 7.21 | 2.67 | 54.71 |
| 2. Dried pea meal obtained from splitting process.. | 26.87 | 8.69 | 2.45 | 3.21 | 2.20 | 56.58 |
| 3. Pea meal—W. Thompson". | 16.97 | 9.95 | 1.24 | 6.86 | 2.61 | 62.37 |
| 4. Crushed peas—Thorp.... | 27.12 | 10.23 | 2.01 | 7.23 | 3.70 | 49.71 |
| 5.—Pea meal—Tillson ...... | 22.50 | 11.57 | 1.53 | 6.82 | 2.33 | 55.25 |
| 6. Pea meal, 1902............ | 20.29 | 12.64 | 2.71 | 8.43 | 3.01 | 52.92 |
| 7. Pea meal, 1903............ | 25.16 | 11.79 | 1.93 | 6.51 | 2.87 | 51.74 |
| 8. Pea meal, 1903........... | 20.11 | 11.65 | 1.21 | 10.09 | 3.26 | 53.68 |
| Average ............... | 23.27 | 10.34 | 1.90 | 7.04 | 2.83 | 54.62 |
| *Pea Hulls or Pea Bran.* | | | | | | |
| 1. Pea hulls................. | 7.12 | 8.12 | 0.83 | 56.52 | 2.23 | 25.18 |
| 2. Tillson's pea bran......... | 9.56 | 7.60 | 2.99 | 49.10 | 2.88 | 27.87 |
| 3. Thompson's pea bran...... | 12.00 | 7.93 | 0.55 | 54.35 | 2.88 | 22.29 |
| 4. Ground pea bran—J Wilson | 15.66 | 7.35 | 3.54 | 25.25 | 3.08 | 45.12 |
| 5. Pea bran—Tillson & Co.... | 8.12 | 5.96 | 2.37 | 47.32 | 2.78 | 33.45 |
| 6. Pea bran—Murton........ | 9.06 | 8.23 | 2.52 | 44.79 | 3.27 | 32.13 |
| 7. Pea bran, 1902............ | 9.57 | 7.24 | 1.42 | 39.53 | 3.26 | 38.98 |
| 8. Pea bran, 1902.... ...... | 10.21 | 6.53 | 0.46 | 24.27 | 3.59 | 54.94 |
| 9. Pea bran, 1902: .......... | 9.08 | 5.41 | 0.30 | 52.63 | 2.98 | 29.60 |
| 10. Pea bran, 1903........... | 7.49 | 9.75 | 0.33 | 54.24 | 2.60 | 25.59 |
| 11. Pea bran, 1903.... ...... | 8.35 | 6.23 | 0.37 | 48.33 | 2.55 | 34.17 |
| 12. Pea bran, 1903............ | 11.42 | 8.57 | 0.60 | 31.69 | 3.05 | 44.67 |
| 13. Pea bran, 1903............ | 12.90 | 8.72 | 2.43 | 18.93 | 2.87 | 54.15 |
| Average................ | 10.04 | 7.51 | 1.44 | 42.07 | 2.92 | 36.01 |
| *Mixed Chop.* | | | | | | |
| 1. Rye 1-5 Oats—R. Harvey. | 12.71 | 13.48 | 5.95 | 4.44 | 5.39. | 58.03 |
| 2. Wheat ½ Oats—R. Harvey. | 13.53 | 10.11 | 5.26 | 9.92 | 6.59 | 54.59 |
| 3. Rye, Oats, Wheat—Equal parts—R. Harvey........ | 13.41 | 11.52 | 5.39 | 7.29 | 6.71 | 55.68 |
| 4. Oats, Wheat, Barley and Buckwheat—R. Harvey... | 13.81 | 13.15 | 3.53 | 10.24 | 6.39 | 52.88 |
| 5. Grain Meal (Peas and Oats.) | 20.66 | 9.53 | 4.32 | 14.21 | 3.59 | 47.69 |
| 6. Mixed Chop (March 26,'03) | 9.37 | 9.95 | 2.97 | 5.65 | 1.48 | 70.58 |
| 7. Farmel.................. | 9.75 | 8.50 | 4.10 | 9.98 | 3.35 | 64.32 |
| 8. Oats and Corn .......... | 8.50 | 12.56 | 2.95 | 18.71 | 2.01 | 55.27 |
| 9. Oat Chop, 1902............ | 9.87 | 10.36 | 4.75 | 9.73 | 3.54 | 61.75 |
| 10. Oat Chop, 1902............ | 10.24 | 9.27 | 5.32 | 8.72 | 3.27 | 63.13 |
| 11. Oat Chop, 1902............ | 8.37 | 11.01 | 5.62 | 9.54 | 2.99 | 62.47 |
| 12. Oat Chop, 1902 ........... | 14.79 | 10.39 | 4.96 | 10.36 | 3.21 | 56.29 |
| 13. Oat Chop, 1902............ | 11.01 | 8.65 | 3.84 | 9.75 | 2.25 | 64.50 |
| 14. Oat Chop, 1903............ | 12.87 | 13.42 | 5.30 | 9.31 | 2.64 | 56.46 |
| 15. Oat Chop, 1903............ | 9.36 | 12.96 | 5.24 | 9.50 | 2.37 | 60.57 |
| 16. Peas and Oats, 1903........ | 14.37 | 12.27 | 5.42 | 12.67 | 3.79 | 51.48 |
| 17. Peas and Oats, 1903........ | 15.29 | 10.85 | 4.26 | 12.12 | 2.98 | 54.50 |
| 18. Peas and Oats, 1903........ | 11.98 | 13.16 | 4.79 | 14.98 | 4.62 | 50.47 |
| 19. Peas and Oats, 1903........ | 20.25 | 10.21 | 3.81 | 11.58 | 3.75 | 50.40 |
| 20. Peas, Oats, and Wheat, 1903 | 16.75 | 11.72 | 4.79 | 12.25 | 6.61 | 47.88 |
| 21. Peas, Oats, and Wheat, 1903 | 12.60 | 13.09 | 4.25 | 20.16 | 5.83 | 43.47 |
| Average................ | 12.81 | 11.27 | 4.61 | 11.00 | 3.96 | 56.35 |

## Pea Meal.

A glance at the foregoing table shows a variation of from 16.97 to 27.13 per cent. of protein. The average percentage of protein in the eight samples is 23.27, which is practically 3 per cent. above the average of four samples recorded by American authorities. The samples of pea meal forwarded by Mr. Thompson, of London, contained a very considerable amount of hulls. To this cause alone we attribute the low protein content of this sample. It is nevertheless possible that the fact that peas were badly damaged by the weevil may have had something to do with the low percentage of protein.

If we are to select food, taking protein as the standard, pea meal would stand very high on our list of concentrated feeding-stuffs. As peas are grown to a limited extent on many farms in our Province, such meal could scarcely be called a commercial feeding-stuff; nevertheless, we have included pea meal under this general heading, because there are certain sections in Ontario where peas are not grown to any extent, and in such localities feeders are dependent upon manufacturers or dealers for their supply of pea meal.

As will be seen in the above table of composition, pea meal would make an excellent food to supplement some of our home grown fodder. Besides showing a very high protein content, pea meal also contains a fair percentage of fat and soluble carbohydrates. The relative percentage of crude fibre is moderately low. Moreover, from digestion experiments carried on by this Station, we are led to believe that the crude fibre of pea meal is digested to a far greater extent than is the crude fibre of some of the by-products which will be noted later on.

## Pea Bran or Hulls.

Thirteen samples of pea bran were analysed. With the exception of one sample, obtained from J. Wilson, the protein content varied from seven to thirteen per cent. The high protein content of Mr. Wilson's sample was, no doubt, due to the fact that it contained quantities of fine pea meal or dust. Such a sample of pea bran would make a very excellent supplement to our coarse cattle foods. The percentage of crude fibre in most cases is very high. I may state, however, that we fed three sheep for a period of one month on pea hulls alone. At the end of the experiment the sheep were weighed, and it was found that they weighed exactly the same as at the beginning of the feeding period. The digestibility of the different components of the pea hulls was at the same time tested, and the results obtained go to show that the digestion co-efficient of the crude fibre of the pea bran was 69; i. e., for every hundred pounds of crude fibre fed 69 pounds were digested. From these facts we are led to believe that the feeding value of pea bran is greater than the low protein content would indicate. It must not be gathered from this that we would recommend this food in preference to those richer in protein.

On the contrary, farmers and dairymen should always aim at securing a fair quantity of protein in any food which is meant to supplement a ration of corn fodder, hay, ensilage, or other home grown feeds. Pea bran, however, is not entirely useless, and might, under certain conditions, serve as a useful component in a maintenance diet.

## Mixed Chop.

In the twenty-one samples of chop analysed the percentage of protein was found to vary between 8.37 and 20.66. The average protein content of these samples was 12.81 per cent. A glance at the table will show that what is ordinarily called chop may be a mixture of various grains grown on the farm. The mixture of oats and corn shows a low protein content when compared, for example, with peas and oats. The practical conclusion to be drawn from this fact is that the feeder should, other conditions being equal, select the richer of the two to supplement a ration made up largely of hay, ensilage, and roots, more especially if this ration be intended for dairy cows.

The above table of composition shows that chop is valuable food; and where the average farmer has an abundance of such food at his disposal it would be folly for him to purchase many of the by-products at present sold without any guarantee as to their composition. Furthermore, experiments conducted by Professor Day on fattening steers appear to indicate that a ration containing a rather wide nutritive ratio will give more economical gains than one possessing a relative narrow nutritive ratio. For fattening purposes, therefore, we believe that chop, such as mentioned in the foregoing table, would supply all the nitrogenous material necessary. If, however, the production of milk were the object, then it might be advisable to select a food containing a greater quantity of protein.

## Wheat Middlings.

Upon inspecting the analyses of the samples of middlings, recorded in this Bulletin, the reader will be struck by the uniformly low percentage of moisture. The average percentage of moisture recorded by American chemists is approximately two per cent. higher than that found in the twenty-one samples analyzed in our laboratory. I may state that as soon as these samples arrived in our laboratory they were at once placed in bottles with ground glass stoppers to prevent any evaporation of moisture, and in every case extreme care was exercised in determining accurately the moisture content of the samples. The fact that any sample of food contains a low per centage of moisture is of great importance to the feeder, inasmuch as, other things being equal, he obtains a larger amount of nutritive material in a food containing a low percentage of moisture than he would if the moisture content were even one per cent. higher.

| FOODS ANALYZED | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Wheat Middlings.* | | | | | | |
| 1. Thorp's Middlings......... | 15.75 | 8.70 | 3.99 | 4.91 | 3.58 | 63.07 |
| 2. Middlings—Tillsonburg.... | 15.94 | 9.12 | 4.40 | 3.96 | 3.92 | 62.66 |
| 3. Middlings—Goldie Co., Ayr | 16.26 | 10.28 | 3.26 | 3.70 | 3.65 | 62.85 |
| 4. Middlings—Frontenac Co.. | 17.66 | 8.29 | 4.10 | 3.91 | 4.25 | 61.79 |
| 5. Middlings................ | 15.43 | 10.53 | 3.03 | 4.48 | 4.12 | 62.41 |
| 6. Middlings................ | 13.79 | 9.70 | 2.71 | 4.28 | 3.86 | 65.66 |
| 7. Middlings................ | 16.45 | 9.42 | 4.89 | 2.93 | 3.79 | 62.52 |
| 8. Middlings................ | 16.62 | 10.52 | 4.25 | 3.25 | 3.85 | 61.51 |
| 9. Middlings................ | 16.65 | 10.75 | 3.99 | 5.40 | 4.20 | 59.01 |
| 10. Middlings................ | 15.46 | 11.21 | 3.65 | 2.72 | 4.00 | 62.96 |
| 11. Middlings................ | 16.32 | 9.69 | 4.60 | 3.99 | 3.47 | 61.93 |
| 12. Middlings................ | 12.73 | 9.73 | 2.99 | 8.62 | 3.61 | 62.32 |
| 13. Middlings................ | 12.97 | 11.75 | 3.62 | 8.50 | 3.20 | 59.96 |
| 14. Middlings................ | 13.47 | 10.62 | 3.75 | 3.78 | 3.12 | 65.26 |
| 15. Middlings................ | 15.65 | 10.40 | 3.00 | 3.21 | 3.05 | 64.69 |
| 16. Middlings................ | 17.10 | 8.62 | 4.11 | 2.50 | 4.04 | 63.63 |
| 17. Middlings................ | 15.32 | 9.77 | 4.00 | 5.42 | 3.79 | 61.70 |
| 18. Middlings................ | 17.25 | 10.02 | 3.65 | 5.00 | 4.21 | 59.87 |
| 19. Middlings................ | 14.33 | 11.51 | 3.97 | 2.92 | 3.50 | 63.77 |
| 20. Middlings................ | 17.12 | 12.05 | 5.52 | 2.45 | 3.20 | 59.66 |
| 21. Middlings................ | 14.80 | 9.35 | 4.69 | 3.29 | 3.60 | 64.27 |
| Average................ | 15.54 | 10.10 | 3.92 | 4.26 | 3.72 | 62.46 |
| *Wheat Bran.* | | | | | | |
| 1. Bran, T. E. Simpson—Merlin | 15.00 | 7.86 | 4.20 | 8.58 | 6.29 | 58.07 |
| 2. Bran, Goldie Milling Co. Ayr | 13.75 | 11.11 | 3.70 | 7.36 | 2.90 | 61.17 |
| 3. Bran from Fall Wheat..... | 14.56 | 9.19 | 3.20 | 10.59 | 6.05 | 56.41 |
| 4. Bran from Manitoba Wheat | 13.50 | 12.23 | 4.50 | 7.04 | 5.62 | 57.11 |
| 5. Bran, Frontenac Milling Co. | 17.53 | 11.71 | 3.11 | 8.41 | 5.09 | 54.15 |
| 6. Wheat bran—Guelph...... | 14.87 | 8.55 | 3.62 | 9.54 | 6.31 | 57.11 |
| 7. Wheat bran—Tillson & Co.. | 16.87 | 11.00 | 3.62 | 9.54 | 6.31 | 52.66 |
| 8. Bran—Meyer's Milling Co.. | 15.25 | 12.24 | 4.43 | 9.21 | 5.20 | 53.67 |
| 9. Bran .................... | 14.21 | 9.75 | 3.10 | 7.20 | 5.40 | 60.34 |
| 10. Bran .................... | 14.30 | 10.43 | 3.91 | 9.96 | 2.20 | 59.20 |
| Average ................ | 14.99 | 10.40 | 3.74 | 8.74 | 5.14 | 56.99 |
| *Low Grade Flour.* | | | | | | |
| Low grade flour—T. E. Simpson | 12.99 | 8.71 | 2.25 | 0.29 | 1.51 | 74.25 |
| Flour—T. E. Simpson, Merlin. | 9.85 | 13.37 | 4.85 | 0.49 | 1.93 | 61.51 |
| Low grade flour—R. Harvey... | 13.00 | 10.97 | 3.65 | 0.53 | 2.21 | 69.64 |
| Average................ | 11.94 | 11.02 | 3.58 | 0.44 | 1.88 | 71.13 |
| Thorp's crushed wheat........ | 13.73 | 7.92 | 2.59 | 3.32 | 1.62 | 70.82 |
| *Shorts.* | | | | | | |
| 1. Shorts—R. Harvey........ | 15.60 | 8.59 | 3.99 | 3.32 | 3.91 | 64.59 |
| 2. Shorts—Pembroke Mill Co. | 16.16 | 9.37 | 4.55 | 5.93 | 5.08 | 58.91 |
| 3. Shorts—T. E. Simpson.... | 16.25 | 11.37 | 5.02 | 5.51 | 4.52 | 57.33 |
| 4. Shorts—Frontenac Mill Co. | 16.06 | 8.21 | 4.26 | 3.31 | 3.95 | 64.21 |
| Average ............... | 16.01 | 9.38 | 4.46 | 4.52 | 4.37 | 61.26 |

A few samples analysed showed an abnormally high percentage of crude fibre. A microscopic examination of these samples revealed the presence of considerable quantities of wheat bran. I may say that these samples were obtained on the market so that their source could not be traced. Samples Nos. 12 and 13 indicate almost as much crude fibre as is found in pure wheat bran, which rarely runs over ten per cent. In samples of pure wheat middlings, the percentage of crude fibre usually varies between 2.50 and 6 per cent. We are glad to say, on account of the widespread use of wheat middlings, that the samples examined were entirely free from corn bran or other adulterants of like character.

## Wheat Bran.

In the above table the percentage composition of ten samples of wheat bran shows a variation of from 13.50 to 17.53 per cent. of protein, and from 3.10 to 4.50 per cent. of fat. It will be noticed that some of the samples of bran analysed were obtained from fall wheat, others from Manitoba spring wheat, and still others are not designated. Every sample of bran was of good quality, and contained no adulterants which could be detected other than a few particles of broken wheat.

Wheat bran is probably one of our best known by-products. It contains protein, fat, ash, and soluble carbohydrates in such proportion as to make it an exceedingly valuable component of a dairy ration. Only two samples of the ten analysed showed less than 14 per cent. of protein. If the percentage of protein falls much below 14 per cent., the chances are that the bran has been mixed with something of inferior quality. In the mentioned case, however, no adulterant could be detected.

## Low Grade Flour.

Three samples of low grade flour were analysed. These show an average of 11.94 per cent. of protein, as well as 3.58 per cent. of fats, and 71.13 per cent. of soluble carbohydrates. For some reason the quantity of protein in sample No. 2 falls considerably below the average. It will be noticed that the percentage of moisture is much higher than in samples 1 and 3. As stated in the introduction, a high moisture content in a feeding-stuff is a decided detriment, in that it not only decreases the actual amount of food components present, but it also favors the growth of moulds, and these hasten the decomposition of valuable food materials.

The results of experiments at some of the American Stations furnish evidence that the amount of soluble carbohydrates and fat is very greatly reduced by the action of moulds. In the case of bread as much as 75 per cent. of the dry matter was lost. This loss was noted chiefly in the carbohydrates. In other experiments with peanut cake the fat content was reduced by mould from 12 to less than 1 per cent. While the writer does not mean to state that the percentage of moisture noticed in sample No. 2 is sufficient to cause such serious loss as that just mentioned, yet the amount of moisture is sufficient to warrant a note of warning on this point. It might also be added that is some cases farmers sustain very serious losses in valuable food materials through improper attention to the ground chop and corn meal. In all cases where the new grains are ground, especially if the grains be soft, the chop should be spread out in some convenient bin or floor in order that the excess of miosture may have a chance to evaporate. In this way the loss resulting from the development of moulds or bacteria may be eliminated or checked to a great extent.

The samples of flour designated as "low grade," although not suitable for bread-making purposes, could be advantageously and economically used as food for pigs. It must be remembered, however, that flour is a very heavy food, and unless it is fed along with some other feeding-stuff of a lighter character, there is danger that the digestive apparatus of the pig may become clogged. Because of this danger, greater care must be observed in feeding pigs on a ration of milk and flour than in feeding milk and middlings, as the latter food contains quantities of bran, which lighten a food very effectively.

Only one sample of crushed wheat was examined. This sample is of very good quality, and would make an excellent substitute for shorts in a ration for young pigs.

### Shorts.

The figures in the above table show an average of 16.01 per cent. of protein, 4.46 per cent. of fat, and 61.26 per cent. of soluble carbohydrates This by-product possesses very high feeding value. It might be used to advantage in supplementing a ration low in protein, provided the animals could be induced to eat it readily. For young pigs, or breeding sows this by-product makes an excellent feed. The young pigs eat it readily and thrive admirably on a ration of shorts and skim milk. In the estimation of many practical feeders this is one of our most valuable by-products, although not equal to low grade flour for fattening hogs.

### Beeswing.

This by-product is the outside layer of the wheat hull, and is, therefore, a special form of bran. This bran is removed from the wheat (which has been previously moistened with cold water), by the action of a cylinder running at a high rate of speed against an outside case. In this process the kernel of the wheat remains unbroken.

A glance at the analysis is sufficient to show us that this by-product contains a larger amount of crude fibre than does our average bran.

Again, we note that the average amount of protein in ordinary bran is approximately fifteen per cent., while in the by-product under discussion the protein content drops to less than ten per cent., which is slightly above the minimum allowable percentage of protein in any feed. The least quantity of protein that any food should contain is 7 per cent. That is to say, it is doubtful if any feed with less than 7 per cent. of protein is a wise purchase unless under exceptional circumstances. Even average cob meal contains nearly 8 per cent. protein. Experiments have shown that, as a rule, when the quantity of protein present in a feed falls below 7 per cent, its place is taken by crude fibre, consequently the purchaser does not receive any greater amount, if as much, of the more digestible forms of carbohydrates than if the protein were furnished. The by-product at present under discussion proves to be quite a marked exception to the general rule. In a series of digestion experiments which we have conducted with this food, we have found that not only is there a very high percentage of digestible soluble carbohydrates present, but the crude fibre also possesses a high digestion co-efficient. It must also be remembered in this connection that in the samples of Beeswing examined we found more than 7 per cent. of protein.

## Cotton Seed Meal.

This by-product in the manufacture of cottonseed oil contained in the following manner : The hull of the cottonseed is removed, the kernel is then cooked and subjected to pressure to remove the oil. The residue (cotton seed cakes) is then pulverized.

The five samples examined were fairly constant in composition. Cottonseed meal is rich in protein, and contains also a high percentage of ether extract or fat.

This by-product must be used with caution, as calves and pigs have been killed by continued use of this food. In the case of milch cows a few pounds per day may be fed, but many owners of live stock regard it as very dangerous food to place at the disposal of the ordinary hired man, because carelessness in regard to the number of pounds of this by-product fed will very quickly result in serious derangement of the digestive organs of the animals. Furthermore, in a ration for young pigs it has been frequently noticed that if cottonseed meal be used to balance a ration of these animals, the animals are apparently poisoned thereby. For the average feeder, therefore, the advice would be to leave cottonseed meal out of a ration intended for these animals.

## Cotton Seed Hulls.

Four samples of cotton seed hulls were analyzed. As will be noticed, the percentage of protein is very low. Average percentage 4.45. The percentage of crude fibre is very high. This by-product is not recommended as a cattle food, as it contains a very low percentage of protein

| FOODS ANALYZED | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Soluble Carbo-hydrates. | Ash. |
|---|---|---|---|---|---|---|
| *Beeswing.* | | | | | | |
| 1. Beeswing—P. McIntosh ... | 9.36 | 7.21 | 0.47 | 19.56 | 2.01 | 61.39 |
| 2. Beeswing, 1903 .......... | 2.23 | 7.42 | 0.39 | 18.76 | 2.12 | 61.08 |
| 3. Beeswing, 1903.......... | 9.20 | 6.17 | 0.38 | 16 25 | 2.73 | 65.27 |
| Average .............. | 9.60 | 6.93 | 0.41 | 18.19 | 2.29 | 62.58 |
| *Ground Cotton Seed Meal.* | | | | | | |
| 1. Cotton Seed Meal ......... | 44.61 | 2.68 | 14.49 | 6.14 | 7.00 | 25.08 |
| 2. Cotton Seed Meal ......... | 44.17 | 7.42 | 14.31 | 3.35 | 6.90 | 23.83 |
| 3. Cotton Seed Meal ......... | 43.65 | 8.65 | 13.98 | 5.70 | 7.10 | 20.92 |
| 4. Cotton Seed Meal ......... | 44.10 | 4.43 | 14.69 | 5.63 | 7.31 | 26.84 |
| 5. Cotton Seed Meal ......... | 44.37 | 6.51 | 10.75 | 3.05 | 6.23 | 25.09 |
| Average .............. | 44.18 | 5.94 | 13.65 | 4.78 | 6.91 | 24.54 |
| *Cotton Seed Hulls.* | | | | | | |
| 1. Cotton seed hulls........... | 5.14 | 9.51 | 1.37 | 49.32 | 2.21 | 32.45 |
| 2. Cotton seed hulls........... | 3.98 | 10.21 | 1.16 | 45.17 | 1.89 | 37.59 |
| 3. Cotton seed hulls........... | 4.98 | 9.58 | 1.31 | 46.37 | 2.34 | 35.42 |
| 4. Cotton seed hulls........... | 3.72 | 9.63 | 1.39 | 45.53 | 2.19 | 37.54 |
| Average................ | 4.45 | 9.73 | 1.31 | 46.60 | 2.16 | 35.75 |
| *Linseed Meal.* | | | | | | |
| 1. Oil Cake—G. Oil Cake Co. | 32.81 | 9.45 | 7.42 | 10.96 | 6.10 | 33.26 |
| 2. Linseed Meal. ............ | 31.37 | 9.17 | 7.26 | 11.33 | 6 47 | 34.40 |
| 3. Oil Cake—Sample A....... | 31.37 | 9.17 | 7.26 | 11.33 | 5.49 | 35 38 |
| 4. Oil Cake—Sample B....... | 33.94 | 10.38 | 7.33 | 11.57 | 6.28 | 30.50 |
| 5. Flax Seed Meal—W. Hewer. | 23.87 | 4.90 | 11.76 | 6.10 | 5.41 | 47.96 |
| 6. Linseed Meal. ............ | 32.65 | 9.90 | 7.55 | 12 26 | 5.83 | 31.81 |
| 7. Oil Cake (1903)........... | 32.60 | 8.43 | 8.20 | 10.93 | 5.97 | 33.87 |
| 8. Oil Cake (1903)........... | 31.51 | 9.90 | 7.42 | 11.60 | 6.25 | 33.32 |
| 9. Oil Cake (1903)........... | 31.96 | 10.47 | 7.12 | 11.20 | 6.46 | 32.79 |
| 10. Linseed Meal. ............ | 30.27 | 8.93 | 3.61 | 8.93 | 4.73 | 43.53 |
| 11. Linseed Meal........ .... | 27.31 | 10.15 | 8.23 | 10.62 | 5.62 | 38.07 |
| 12. Linseed Meal............. | 26.54 | 7.64 | 4.32 | 12.17 | 6.01 | 43.32 |
| 13. Linseed Meal............. | 29.12 | 9.21 | 4.46 | 9.39 | 5.93 | 41.89 |
| Average............... | 30.41 | 9.06 | 7.07 | 10.64 | 5.89 | 36.93 |
| *Gluten Meal.* | | | | | | |
| 1. Maize Gluten—Wilson.... | 15.00 | 6.51 | 3.73 | 6.65 | 1.80 | 66.31 |
| 2. Gluten Meal.............. | 24.36 | 2.24 | 7.97 | 5.13 | 0.77 | 59.53 |
| 3. Gluten Meal.............. | 31.50 | 9.43 | 8.73 | 1.27 | 0.68 | 49.39 |
| 4. Gluten Meal.............. | 28.65 | 8.79 | 6.84 | 1.43 | 0.84 | 53.45 |
| 5. Gluten Meal.............. | 16.23 | 6.31 | 7.02 | 5.64 | 0.39 | 64.41 |
| 6. Gluten Cake ............. | 19.27 | 10.82 | 5.21 | 5.93 | 0.64 | 58.13 |
| 7. Gluten Cake............ . | 22.37 | 4.73 | 9.23 | 4.72 | 1.58 | 57.37 |
| 8. Gluten Meal.............. | 29.65 | 7.61 | 6.27 | 3.65 | 0.89 | 51.93 |

| FOODS ANALYZED. | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Gluten Meal.* | | | | | | |
| 9. Gluten Meal.............. | 30.90 | 5.12 | 10.22 | 5.81 | 0.92 | 47.03 |
| 10. Gluten Meal.............. | 27.35 | 5.43 | 15.00 | 1.29 | 1.25 | 49.68 |
| 11. Gluten Meal.............. | 21.73 | 9.64 | 8.83 | 4.31 | 0.68 | 54.81 |
| 12. Gluten Meal.............. | 18.59 | 8 23 | 7.21 | 6.27 | 0.75 | 58.95 |
| 13. Gluten Meal.............. | 17.65 | 5.61 | 7.42 | 6.15 | 0.83 | 62.34 |
| 14. Gluten Meal.............. | 34.74 | 6.91 | 5.71 | 2.00 | 0.37 | 50.27 |
| 15. Gluten Meal.............. | 19.57 | 7.54 | 8.31 | 1.82 | 0.57 | 62.19 |
| 16. Gluten Meal.............. | 25.44 | 8.25 | 14.78 | 4.61 | 0.62 | 46.30 |
| 17. Gluten Meal.............. | 25.86 | 4.64 | 10.21 | 1.52 | 0.92 | 56.85 |
| 18. Gluten Meal.............. | 19.73 | 9.10 | 10.62 | 5.98 | 1.15 | 53.42 |
| 19. Gluten Meal.............. | 27.34 | 8.85 | 9.21 | 1.05 | 0.68 | 52.87 |
| 20. Gluten Meal.............. | 29.63 | 8.06 | 8.25 | 2.25 | 0.72 | 51.09 |
| 21. Gluten Meal.............. | 28.70 | 5.92 | 10.12 | 2.93 | 0.50 | 51.83 |
| 22. Gluten Meal.............. | 34.90 | 6.87 | 6.91 | 1.07 | 0.74 | 49.51 |
| Average................ | 24.96 | 7.12 | 8.54 | 3.70 | 0.83 | 54.85 |
| *Gluten Feed.* | | | | | | |
| 1. Gluten Feed..... ....... | 27.73 | 11.59 | 3.06 | 6.97 | 0.21 | 50.44 |
| 2. Gluten Feed.............. | 27.51 | 6.33 | 8.91 | 8.25 | 1.19 | 47.81 |
| 3. Gluten Feed.............. | 24.87 | 11.50 | 7.23 | 4.49 | 0.26 | 51.65 |
| 4. Gluten Feed.............. | 23.75 | 9.42 | 6.44 | 6.82 | 1.63 | 51.94 |
| 5. Gluten Feed.............. | 25.75 | 5.45 | 6.13 | 5.73 | 0.85 | 56.09 |
| 6. Gluten Feed.............. | 28.34 | 9.55 | 4.21 | 6.15 | 0.89 | 50.86 |
| 7. Gluten Feed.............. | 26.43 | 10.15 | 8.23 | 7.36 | 0.42 | 47.41 |
| 8. Gluten Feed........... ... | 26.21 | 5.42 | 7.52 | 5.75 | 0.87 | 54.23 |
| 9. Gluten Feed.............. | 22.98 | 8.63 | 6.82 | 6.50 | 0.93 | 54.14 |
| 10. Gluten Feed.............. | 27.37 | 10.45 | 12.18 | 3.92 | 0.56 | 45.52 |
| 11. Gluten Feed.............. | 23.58 | 8.43 | 8.40 | 5.17 | 0.72 | 53.70 |
| 12. Gluten Feed.............. | 26.79 | 9.27 | 9.61 | 3.99 | 0.64 | 49.70 |
| 13. Gluten Feed.............. | 23.21 | 6.23 | 9.82 | 4.25 | 1.14 | 54.85 |
| 14. Gluten Feed.............. | 25.92 | 9.47 | 12.65 | 5.42 | 0.62 | 45.92 |
| 15. Gluten Feed.............. | 24.61 | 6.42 | 7.73 | 6.49 | 0.43 | 54.32 |
| 16. Gluten Feed.............. | 26.81 | 8.62 | 5.23 | 6.83 | 0.92 | 51.59 |
| 17. Gluten Feed.............. | 24.32 | 8.94 | 3.66 | 6.62 | 1.61 | 54.85 |
| Average................ | 25.65 | 8.61 | 7.52 | 5.92 | 0.82 | 51.47 |
| *Corn Chop.* | | | | | | |
| 1. Corn Chop—T. E. Simpson. | 11.07 | 8.79 | 4.76 | 3.10 | 1.18 | 71.10 |
| 2. Thorp's Crushed Corn..... | 11.28 | 10.66 | 4.34 | 2.08 | 1.39 | 70.25 |
| 3. Corn Chop, 1902.......... | 9.58 | 11.32 | 4.37 | 2.35 | 1.73 | 70.65 |
| 4. Corn Meal, 1902........... | 10.32 | 12.16 | 5.16 | 1.25 | 1.24 | 69.87 |
| 5. Corn Meal, 1902........... | 8.61 | 10.34 | 5.03 | 1.37 | 1.00 | 73.65 |
| 6. Corn Meal, 1902........... | 9.28 | 9.31 | 3.25 | 2.18 | 1.20 | 74.78 |
| 7. Corn Meal, 1902........... | 9.54 | 4.20 | 3.21 | 2.60 | 0.98 | 79.47 |
| 8. Corn Meal, 1903 .......... | 6.54 | 11.71 | 4.71 | 1.85 | 1.98 | 73.21 |
| 9. Corn Meal. 1903 ......... | 7.32 | 11.15 | 4.44 | 1.46 | 1.76 | 73.87 |
| 10. Corn Meal, 1903.......... | 10.05 | 8.43 | 5.45 | 1.11 | 1.54 | 73.42 |
| Average................ | 9.36 | 9.80 | 4.47 | 1.93 | 1.40 | 73.04 |

and fat. Moreover, the crude fibre is not only largely indigestible, so that the digestive juices of the animal do not extract much nutriment from it, but, what is still more important, crude fibre renders the rest of the food less digestible by protecting it from the action of the digestive fluids. This by-product is, therefore, practically worthless, and to the average farmer it would be dear at any price. For, not only is the quantity of protein extremely small, but by far the larger percentage of carbohydrates exists in a very indigestible form. To move these indigestible ingredients from one part of the alimentary canal to another necessitates the expenditure of energy. Thus we see that energy derived from a digestible portion of a ration may be used up in eliminating the indigestible portions from the system. Materials such as cotton seed hulls which contain large quantities of crude fibre in a highly indigestible form are, therefore, a decided detriment to a ration.

## Linseed Meal.

This product is the residue left after extracting the oil from flaxseed with naphtha, benzine, or a similar solvent of oily matter. In the extraction of linseed oil by the old process the flaxseed was subjected to pressure. The new process admits of more perfect removal of the oil from the seed; therefore, linseed meal obtained from the "new process," as a rule, contains more protein and less fat than the "old process" meal.

The thirteen samples of linseed meal examined are all of "new process" manufacture. The table of composition shows an average of 30.41 per cent. of protein in the thirteen samples examined. Linseed meal is therefore, a highly concentrated food, and may be used in moderate quantities to correct the deficiency of protein in some of our home-grown feeding-stuffs. As this meal also contains a high percentage of crude fat, it may have a beneficial mechanical effect in rendering the passage of the other components of a ration through the alimentary canal less difficult.

Linseed meal has been advocated as a component of a ration for milch cows, and many of our most intelligent dairymen have fed it with good success. It is also claimed that a small quantity of linseed meal fed in a ration to horses will give these animals a glossy coat, which is an indication of a thrifty condition.

There are two kinds of linseed cake or meal, the one containing the hulls of the seed and the other the decorticated meal. The analysis in the foregoing table represents the composition of thirteen samples of the latter food. As a component of a ration for all kinds of animals, it is one which in the experience of a great number of practical feeders has given good results. Some feeders object to the use of this food, because when mixed with water it has a sticky consistency. This, however, should not be a serious objection if the results obtained from the use of this food indicate greater value than those obtained from the use of other by-products.

## Gluten Meal.

Gluten meal is the residue, or part of the residue, from the manufacture of starch and glucose. The process of manufacture consists essentially in the separation, first, of the germ and hull from the starch and gluten; and second the final separation of gluten from the starch. The residue may, therefore, consist either of three products, a mixture of gluten, germ, and hulls, a mixture of any two of these components, or any single component. In any case, however, the by-products are parts of the original corn, but when prepared for the market they differ from it and from each other in the amount of food constituents, and also in appearance.

The entire residue called "gluten feed" is of a bright yellow color: and is of a much more bulky character than corn meal. The increased bulk is due to the presence of a larger proportion of bran in the gluten feed. Gluten by itself is distinguished by a high content of protein and a deeper yellow color. This product is commonly called gluten meal.

The twenty-two samples analysed were either secured on the market, or forwarded to us by farmers in Ontario. The figures show quite a wide variation in composition. It will be observed, however, that the protein content is high and the percentage of crude fibre is correspondingly low.

It was noted in a previous part of this bulletin that certain foods rich in protein are also rich in ash material. The result of our work shows that an exception is formed by concentrated feeds, which are by-products, where the seeds are treated with large quantities of water. (Note the example in the above table.) Such a food should be fed with caution to young stock that consume but little roughage and require a liberal supply of ash material for the formation of bone.

## Gluten Feed.

Gluten feed, like gluten meal, is a by-product in the manufacture of starch and glucose from Indian corn. The waste products are relatively much richer in oil and protein than is corn.

A great many dairymen are vey well satisfied with this feed. It contains a fair amount of protein, and hence is a very useful material to supplement home-grown foods.

## Corn Chop.

Ten samples of corn chop were analysed. The figures in the above table show a variation of from 6.54 to 11.28 per cent. of protein. Comparing the average percentage composition of corn chop with that of wheat middlings, we note that the figures show a very slight difference in the fat content of these two feeding-stuffs. The average protein content is, however, about 5 per cent. higher in the case of middlings. The percentage of crude fibre is much the same in both middlings and corn meal. Another matter which the practical agriculturist has to consider in feeding young and growing animals is the quantity of ash, or bone forming material, which a food may contain. In comparing the average percentage of ash in wheat middlings with that of corn the figures reveal a vey marked difference in favor of the wheat middlings.

It has been said in another part of this bulletin, that the ash constituents of a feeding-stuff are of great importance to young and growing animals. The fact that gluten meal and such by-products contain a low percentage of ash has also been mentioned. These products, however, are used by comparatively few of our farmers. Corn meal, on the other hand, is used very extensively in certain parts of Ontario; therefore a few facts concerning the quantity and quality of the ash of corn meal as compared with the ash material required by the animal body may not be out of place. The complaint has often been heard that hogs fed on corn alone have weak bones. The reason for this is very apparent when we consider the amount of ash required by these animals for the building up of the bone, with the percentage of ash indicated in the foregoing table, which is 1.4 per cent., or 1.4 pounds in 100 pounds of the corn meal. Of this 1.4 pounds .032 of a pound is lime and .67 of a pound is phosphoric acid. *Now, according to Professor Henry of Madison, Wis., 534 pounds of corn will produce 100 pounds of gain. And since this amount of corn contains 7.47 pounds of ash, of which .69 per cent. is phosphoric acid and lime, there is only .051 pounds of the principal bone-forming materials supplied to the growing hog. Now, let us consider the requirements of the hog. His increase in weight is 100 pounds, of which, according to Lawes and Gilbert, 2.9 per cent. is ash. Of this 99.0 per cent. is bone ash. From these figures it is apparent that in 100 pounds gain 2.87 pounds of bone ash has been formed, of which 97.25 per cent. is made up of lime and phosphoric acid, or 2.79 pounds of lime and phosphoric acid are necessary under normal conditions to supply the ash material necessary for 100 pounds of growth. Therefore, if corn meal be fed alone there will be a deficiency of 2.70 pounds of the necessary ash constituents of bone. Hence, it is not surprising that animals fed on such a ration are weak boned.

What has been said regarding the ash material required for the building up of the bone in the case of the growing hog is, in the main, true of all young and growing animals. Such animals require from five to seven per cent. of ash in their food, and of this about 97.0 per cent. should be lime and phosphoric acid. Therefore when corn is fed to young animals it should be mixed with other foods containing a much higher percentage of ash in order that the bone forming material of these animals may be furnished in sufficient quantity.

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*Iowa Agriculturist, April, 1904.

| FOODS ANALYZED. | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Corn Bran.* | | | | | | |
| Corn Bran—P. McIntosh..... | 11.81 | 8.32 | 2.98 | 11.02 | 1.35 | 64.52 |
| Corn Bran—Tillson & Co...... | 8.75 | 7.12 | 3.73 | 15.89 | 1.40 | 63.11 |
| Corn Bran, 1903............... | 8.21 | 5.42 | 1.01 | 16.32 | 0.99 | 68.05 |
| Corn Bran, 1902.... ......... | 7.42 | 4.21 | 1.25 | 19.54 | 1.54 | 66.04 |
| Corn Bran, 1902.............. | 7.00 | 4.79 | 1.13 | 18.60 | 0.71 | 67.77 |
| Average................ | 8.64 | 5.97 | 2.02 | 16.27 | 2.20 | 65.90 |
| *Corn Ensilage.* | | | | | | |
| 1. Ensilage, Jan. 17, 1903..... | 9.63 | 5.48 | 2.32 | 31.55 | 6.16 | 44.86 |
| 2. Ensilage, barn silo, Jan. 29. | 10.06 | 7.35 | 2.00 | 32.82 | 6.54 | 41.23 |
| 3. Ensilage, dairy silo, Jan. 31. | 10.50 | 10 21 | 2.55 | 27.65 | 5.59 | 43.40 |
| 4. Ensilage, dairy silo, Feb. 6. | 10.65 | 9.65 | 2.42 | 33.20 | 5.89 | 38.19 |
| 5. Silage, air-dried, Feb. 21st.. | 10.87 | 10.62 | 2.31 | 35.40 | 5.91 | 34.89 |
| 6. Silage, air-dried, Mar. 7th dairy .................... | 10.92 | 10.92 | 2.04 | 34.27 | 6.23 | 35.62 |
| 7. Silage, air-dried, Mar. 19th dairy .................... | 11.01 | 10.63 | 2.00 | 33.60 | 6.80 | 35.96 |
| Average................ | 10.52 | 9.26 | 2.25 | 32.64 | 6.16 | 39.17 |
| *Corn of 1903, Percentage as Calculated in Water-Free Substance.* | | | | | | |
| 1. Green Corn, 1903........... | 10.43 | ........ | 2.78 | 27.37 | 6.81 | 52 61 |
| 2. Field Cured Corn, 1903..... | 10.04 | ........ | 1.31 | 32.64 | 5.15 | 50.86 |
| 3. Silage, 1903............ ... | 9.91 | ........ | 2.73 | 24.35 | 7.49 | 55.52 |
| 4. Silage, 1903................ | 8.53 | ........ | 2.91 | 31.52 | 5.92 | 51.12 |
| 5. Silage, 1903................ | 7.49 | ........ | 2.85 | 34.20 | 6.20 | 49.26 |
| 6. Silage ..................... | 8.21 | ........ | 2.89 | 30.27 | 7.01 | 51.62 |
| 7. Green Corn, 1903........... | 9.99 | ........ | 2.37 | 33.26 | 6.44 | 47.94 |
| 8. Field Cured Corn, 1903..... | 9.49 | ........ | 1.41 | 36.83 | 4.94 | 47.33 |
| 9. Silage, 1903................ | 9.22 | ........ | 2.65 | 27.18 | 8.05 | 52.90 |
| Average................ | 9.26 | ........ | 2.43 | 30.85 | 6.44 | 51.02 |
| *Oat Hulls or Oat Bran.* | | | | | | |
| 1. Oat Bran—P. Stuart....... | 6.04 | 8.24 | 1.30 | 25.13 | 1.21 | 58.08 |
| 2. Oat Hulls, 1903........... | 5.43 | 8.97 | 0.27 | 31.65 | 6.52 | 47.16 |
| 3. Oat Hulls, 1903........... | 3.91 | 10.84 | 0.21 | 35.44 | 5.43 | 44.17 |
| 4. Oat Hulls, 1903........... | 2.26 | 9.38 | 0.69 | 32.50 | 4.47 | 50.70 |
| 5. Oat Hulls, 1903........... | 7.59 | 8.72 | 0.54 | 28.64 | 6.10 | 48.41 |
| 6. Oat Bran—Tillson & Co... | 8.44 | 4.07 | 0.53 | 31.25 | 4.96 | 50.75 |
| 7. Oat Bran—D. R. Ross ..... | 7.13 | 9.59 | 5.11 | 30.22 | 5.85 | 42.00 |
| 8. Ground Oat Hulls ........ | 11.88 | 7.85 | 0.76 | 27.48 | 2.63 | 49.40 |
| 9. Oat Hulls—Martin Bros.... | 6.50 | 9.59 | 0.89 | 15.34 | 7.93 | 59.75 |
| 10. Ph. 44 Oat Bran ......... | 7.70 | 4.10 | 1.92 | 36.15 | 3.80 | 46.33 |
| Average ............... | 6.74 | 8.07 | 1.16 | 29.38 | 4.90 | 49.75 |

## Corn Bran.

What has been said regarding oat hulls holds true, in a general way, of corn bran. This by-product bears to corn the same relation that bran and oat hulls bear to wheat and oats. Corn bran possesses a very low feeding value, but unless added to a feed in large quantities it is not objectionable. If, however, large quantities of such material be mixed with some of our more concentrated by-products, the mixture is worth less money than a concentrated by-product not so adulterated. If the corn bran be sold as a by-product pure and simple, then the buyer has no one but himself to blame if the results obtained from feeding such food prove unsatisfactory. The intelligent feeder of live stock will have very little to do with materials which, like this feed, contain less than 9 per cent. of protein, because most farms produce enough course fodder to supply material of such low grade. It is very true that foods of this general character are sold at a lower price per ton than wheat bran, middlings, gluten meal, and linseed meal, but it should be remembered that a ton of linseed meal contains almost four times as much protein as was present in this feed, and when considered from this standpoint, it may be found that that which seems to be cheapest at the time is really the least economical in the end.

## Corn Grown 1902.

Seven analyses of corn ensilage show an average of 10.52 per cent. of crude protein in the air-dried food. The object of making these several analyses was to study the chemical changes which take place in the protein compounds of corn in the silo. This table does not show any column for amide compounds, but I may say that our work, so far as we are able to judge from present results would indicate that a certain amount of the proteid bodies revert to a lower form during the process of fermentation. The figures on the above table would indicate that the corn in the dairy silo in 1902 was of quite constant composition.

## Analysis of Corn of 1903, Percentage Calculated in Water Free Substance.

The reader will be at once impressed with the fact that whatever be the food value of green corn or corn ensilage, it possesses but a very low percentage of protein. The nine samples analysed in our laboratory show an average of only 9.26 per cent. in water-free substance. Bearing in mind what has been said in the introduction regarding the value of protein in the food of our farm animals, it is apparent that the intelligent feeder must supplement a ration, consisting largely of green corn or ensilage, with a certain amount of a more nitrogenous food.

## Oat Hulls or Oat Bran.

This product is obtained by removing the outer shell of the oat grain. The oats are first kiln dried and are then run through a pair of stones. The product is then run over a wire screen and all the dust is screened out. The kernel and hulls are then passed through a fan which removes the hull and leaves the kernel.

The figures in the above table show a wide variation in the composition of oat hulls. In discussing the value of cotton seed hulls we pointed out the poor economy of feeding a product which contains a high percentage of crude fibre. A glance at the foregoing table shows that oat hulls contain a considerable quantity of crude fibre. This fact would at once convince us that this by-product possess a very low feeding value. But in sections where cattle are fed large quantities of corn meal, oat hulls or similar food-stuffs may exercise a beneficial mechanical effect, in that the food is made lighter and more easily digested.

## Oat Dust.

In the manufacture of oat-meal or rolled oats the grain is first kiln dried and then passed through a stone to remove the hulls. The product is then passed over a screen and the dust removed. This dust is largely composed of a layer which lies between the kernel of the oat and the hull. Small particles of the broken oat. also pass through the screen and these are included in what is termed oat dust.

"Oat dust is not, as has been stated on several occasions, simply dirt and rubbish; on the contrary it is a pure by-product of the oat." Of course, the writer does not mean to claim that it would be impossible to mix an inferior grade of feed with the dust from the oat, and represent the mixture to be pure oat dust. But the combined chemical and microscopic examinations of twenty-three samples of this by-product failed to detect in a single case any foreign material other than finely divided particles of oat hulls, which under the method of manufacture can scarcely be looked upon as adulterant.

Comparing the average composition of oat dust with that of wheat bran, we note that the average quantity of protein in the latter feed is considerably lower than that in the bran. Therefore, if we take the quantity of protein and fat as the standard of purchase,—and it can hardly be denied that such is the correct standard, since materials containing considerable protein are the only ones suitable as additions to the feeding material of the farm,—wheat bran must be regarded as a much more valuable material than oat dust.

The objection might be raised that the purchaser is not getting the carbohydrates in the high-grade material that he would get in some of our lower grade feeds (oat dust for example); but it must be remembered that the feeding materials of the farm usually contain an abundance of carbohydrates. To such an extent is this true, indeed, that home grown

| Foods Analyzed. | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Oat Dust.* | | | | | | |
| 1. Flavelle's Oat Dust, 1900 .. | 9.78 | 6.60 | 5.73 | 18.16 | 4.50 | 55.23 |
| 2. Tillson's Oat Dust......... | 10.97 | 7.17 | 5.53 | 22.60 | 6.23 | 47.50 |
| 3. Oat Dust—D. R. Ross ..... | 13.00 | 10.05 | 4.17 | 16.75 | 5.37 | 50.66 |
| 4. Oat Dust, 1902 ............ | 9.37 | 10.57 | 4.57 | 13.25 | 3.21 | 59.03 |
| 5. Oat Dust, 1902............ | 10.25 | 9.63 | 3.65 | 9.53 | 5.48 | 61.45 |
| 6. Oat Dust, 1902............ | 7.62 | 13.21 | 4.25 | 10.67 | 6.62 | 57.63 |
| 7. Oat Dust, 1902............ | 11.54 | 8.20 | 2.97 | 8.75 | 4.71 | 63.83 |
| 8. Oat Dust, 1903............ | 6.75 | 10.58 | 3.57 | 13.73 | 4.29 | 61.08 |
| 9. Oat Dust, 1903............ | 12.63 | 7.21 | 5.61 | 25.25 | 6.08 | 43.22 |
| 10. Oat Flour—D. R. Ross.... | 13.56 | 6.92 | 5.95 | 6.71 | 4.60 | 62 26 |
| 11. Sutherland's Fine Meal.... | 19.30 | 5.34 | 5.74 | 12.20 | 2.52 | 54.90 |
| 12. Sutherland's Black Dust... | 10.43 | 7.71 | 2.29 | 13.91 | 6.41 | 59.25 |
| 13. Oat Dust, Tillsonburg ..... | 13.85 | 5.05 | 5.33 | 18.25 | 3.28 | 54.24 |
| 14. Oat Dust—Meyer's Mill Co. | 11.07 | 11.11 | 4.83 | 5.15 | 5.95 | 61.89 |
| 15. Oat Dust—P. Stuart ....... | 16.37 | 7.60 | 5.89 | 6.73 | 4.05 | 59.36 |
| 16. Oat Dust—Tillsonburg..... | 16.62 | 12.10 | 5.75 | 15.15 | 4.15 | 46.23 |
| 17. Oat Dust—J. Wilson, Fergus | 13.06 | 14.39 | 6.90 | 11.23 | 2.98 | 51.44 |
| 18. Oat Dust—R. Martin Bros.. | 14.22 | 12.00 | 4.61 | 7.21 | 2.42 | 59.54 |
| 19. White Oat Dust........... | 14.42 | 12.13 | 6.03 | 5.80 | 1.90 | 59.72 |
| 20. Mill Dust, 1903............ | 8.52 | 9.53 | 3.21 | 15.53 | 3.91 | 59.30 |
| 21. Mill Dust, 1903............ | 8.95 | 13.61 | 3.54 | 29.14 | 3.47 | 41.29 |
| 22. Pearl Oat Dust............ | 11.99 | 13.35 | 5.21 | 4.10 | 1.85 | 63.50 |
| 23. Pearl Oat Dust............ | 10.16 | 10.21 | 4.15 | 5.05 | 1.54 | 68.89 |
| Average................ | 11.93 | 9.75 | 4.76 | 12.82 | 4.15 | 56.58 |
| *Oat Siftings.* | | | | | | |
| 1. Oat Siftings—P. Stuart .... | 17.13 | 10.21 | 3.30 | 18.21 | 2.68 | 48.47 |
| 2. Oat Siftings, 1902 ......... | 14.36 | 9.37 | 3.21 | 19.15 | 3.10 | 50.81 |
| 3. Oat Siftings, 1902 ......... | 11.21 | 13.65 | 2.61 | 18.44 | 2.17 | 51.89 |
| 4. Oat Siftings, 1902 ......... | 16.24 | 8.39 | 4.52 | 17.66 | 1.59 | 51.60 |
| 5. Oat Siftings, 1902 ......... | 12.70 | 10.25 | 3.13 | 18.35 | 1.39 | 54.18 |
| Average................ | 14.33 | 10.37 | 3.36 | 18.36 | 2.19 | 51.39 |
| *Oat Feed and Oat Meal.* | | | | | | |
| 1. Oat Feed — W. Thompson. | 10.41 | 5.24 | 3.52 | 8.22 | 2.53 | 74.06 |
| 2. Feed Oatmeal—R. Martin | 17.07 | 10.31 | 3.97 | 8.25 | 4.73 | 55.67 |
| 3. Oats coarsely ground ...... | 12.38 | 8.43 | 3.17 | 11.40 | 3.00 | 61.62 |
| 4. Oats kiln dried............ | 11.60 | 9.92 | 4.15 | 9.56 | 4.01 | 60.76 |
| 5. Oatmeal .................. | 16.95 | 13.25 | 7.31 | 0.83 | 1.85 | 59.81 |
| 6. Oatmeal .................. | 12.80 | 11.17 | 8.24 | 0.66 | 1.29 | 67.84 |
| 7. Hulled Oats .............. | 16.00 | 9.20 | 6.25 | 1.89 | 2.36 | 64.30 |
| *Mill Feed.* | | | | | | |
| 1. Mill Feed — P. McIntosh, | 7.94 | 13.25 | 3.29 | 17.87 | 5.49 | 52.16 |
| 2. { Residue from patent Cer- | 9.23 | 7.42 | 1.01 | 27.51 | 10.97 | 43.86 |
| 3. { eal Foods............. | 8.50 | 9.31 | .98 | 27.78 | 9.34 | 44.09 |
| 4. Mill stuff—W. Bacon...... | 4.75 | 6.58 | 1.56 | 34.35 | 5.34 | 47.42 |
| 5. Mill feed, 1902........... | 8.76 | 12.36 | 3.10 | 19.52 | 4.76 | 51.50 |
| 6. Mill feed, 1902........... | 9.27 | 10.52 | 2.75 | 16.24 | 5.32 | 55.90 |
| 7. Mill feed. ................ | 12.98 | 10.21 | 4.43 | 9.80 | 2.15 | 60.43 |
| 8. Mill feed. ................ | 11.63 | 8.37 | 4.26 | 7.21 | 3.09 | 65.44 |
| 9. Mill stuff................. | 6.54 | 9.67 | 2.15 | 25.42 | 6.53 | 49.69 |
| 10. Mill stuff................ | 3.22 | 10.72 | 1.69 | 20.61 | 7.42 | 56.34 |
| 11. Mill stuff................ | 3.49 | 10.90 | 1.25 | 24.44 | 7.15 | 52.77 |
| 12. Mill stuff................ | 4.84 | 9.62 | 1.11 | 21.27 | 6.21 | 56.95 |
| Average................ | 7.60 | 9.91 | 2.30 | 21.00 | 6.15 | 53.04 |

carbohydrates of higher quality than are furnished by many of these feed substitutes are often wasted on the farm. There is a class of feeders, however, to whom feeding-stuffs low in protein and which contain relatively large amounts of carbohydrates are valuable, namely, those who raise nothing themselves—city feeders of horses and stall-fed cattle. To these feeders, therefore, the quality of the carbohydrates is of greater importance. In the case of the horse, the animal is not provided with the extensive digestive apparatus of the cow. Nevertheless, he requires bulky material in connection with his grain, and he also requires that this bulky material be of good quality.

Referring to the table of composition we notice that the amount of total carbohydrates in oat dust is high, amounting to 69.40 per cent. Of this 12.82 per cent. appears in the form of crude fibre, the remaining 58.58 per cent. being soluble carbohydrates (starch, sugar, gums, etc.). If, therefore, the procuring of carbohydates were the object of the purchase, oat dust should command a high price, inasmuch as this food contains only a moderate amount of these in the form of crude fibre.

## Oat Siftings.

Five samples of oat siftings indicate an average of 14.33 per cent. of protein. The fat content is also well in advance of many of the by-products on our markets. The percentage of crude fibre is rather higher than we would have expected in such a food. The microscopic examination, however, revealed the presence of only particles of finely divided oat hulls which could hardly be considered as an adulterant.

## Oat Feed and Oatmeal.

Sample No. 1 of this table must be considered a low grade food since it contains less than 11 per cent. of protein and less than two per cent. of fat.

Samples Nos. 2 and 7 of this table contain sufficient quantities of protein and fat to warrant us in classifying them as high grade foods. Such a food as No. 7 when mixed with milk or swill would make an excellent food for young pigs.

Two samples of oatmeal were analysed. As this food is not used to any extent as a cattle food, it is quite unnecessary to discuss the variation in composition.

Two samples of oats were analysed. In discussing the composition of oat dust, we observed that horses were usually fed on a ration consisting of bulky food and grain. In most cases the grain ration is made up largely of oats. It is interesting, therefore, to note that the amount of protein in the oat grains is low as compared with some of our concentrated by-products, and yet we seldom hear of oats being replaced in a ration for working horses by any of the highly nitrogenous materials on our market. It may be that the quality of the proteids of the oat grain may have something to do with it; or the amount of fat may influence its nutritive value. Whatever be the cause we know that a component of a ration for work horses this special grain is of particular importance. Let us remember, however, that oats vary as greatly in composition as do some of the by-products we have examined, and that it is important that the amount of protein in oats be as large as possible. Remembering this the intelligent feeder will select the variety of this particular grain which gives the greatest yield with a corresponding decrease of crude fibre.

### Mill Feed.

Comparing the average composition of the foods recorded in this table with those of oat dust, we find that the latter contains a much higher percentage of crude protein and a correspondingly lower percentage of crude fibre. The oat dust must, therefore, be considered the better of the two.

No experiments have yet been conducted at this station to show which of the two foods is the more digestible. We hope, however, to be able in the near future to furnish this very desirable information.

### Barley Dust.

"This by-product in the manufacture of pot and pearl barley is obtained by continued scouring of the grain with a stone. During the process the dust is carried away by means of a suction fan. Should there be any oat grains in the barley, they would also be broken up in the process and would appear in the dust."

The ten samples show an average of 14 per cent. of protein, which is a fair amount in a feeding-stuff. It will be noticed, however, that there is a very considerable amount of crude fibre in this product. For this reason we do not consider it as valuable for feeding purposes as it would be if less fibre were present.

The microscopic examination of these samples revealed in most cases considerable quantities of finely pulverized barley hulls. Such by-products as barley hulls, because of their low digestibility, are very undesirable in a cattle food. Notwithstanding this fact the samples of barley dust examined show a fairly high protein content, and might be advantageously fed to certain classes of keep animals.

### Malt Sprouts.

Dried grains and malt sprouts, by-products from distilleries and breweries, are frequently used as cattle foods. To obtain these products the grain is first caused to sprout, and as a result of this growth the starch of the grain is changed to sugar. The sprouts are then removed and sold by dealers, sometimes in the wet condition, but for shipment they are dried and put up in sacks or barrels.

| Foods Analyzed. | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Barley Dust.* | | | | | | |
| 1. Barley Dust—Thompson .. | 13.91 | 5.29 | 5.22 | 11.58 | 2.80 | 61.20 |
| 2. Barley Dust, Tillsonburg .. | 14.78 | 9.01 | 2.37 | 7.61 | 5.40 | 60.83 |
| 3. Barley Dust — H. Wilson. | 14.50 | 12.90 | 1.22 | 8.51 | 3.00 | 59.87 |
| 4. Barley Dust .. R. Martin | 17.13 | 9.37 | 2.03 | 10.95 | 3.21 | 57.31 |
| 5. Barley Dust, 1902 ........ | 12.40 | 13.65 | 1.12 | 15.43 | 2.95 | 54.45 |
| 6. Barley Dust, 1902 ........ | 15.37 | 10.40 | 2.16 | 19.71 | 3.05 | 49.31 |
| 7. Barley Dust, 1903 ........ | 13.21 | 9.80 | 1.95 | 13.25 | 3.40 | 58.39 |
| 8. Barley Dust. 1903 ........ | 14.30 | 11.43 | 2.30 | 8.97 | 2.91 | 60.07 |
| 9. Barley Dust, 1903 ........ | 11.21 | 12.70 | 1.07 | 10.40 | 3.87 | 60.75 |
| 10. Barley Dust .............. | 13.51 | 10.75 | 1.87 | 17.41 | 3.51 | 52.95 |
| 11. Barley Hulls.............. | 13.72 | 11.53 | 2.83 | 29.37 | 3.23 | 39.32 |
| Average................ | 14.00 | 10.62 | 2.20 | 13.93 | 3.39 | 55.86 |
| *Malt Sprouts.* | | | | | | |
| 1. Malt Sprouts.............. | 29.24 | 8.70 | 1.85 | 15.27 | 7.80 | 37.14 |
| 2. Malt Sprouts.............. | 29.44 | 8.90 | 1.74 | 17.39 | 6.44 | 36.09 |
| Average................ | 29.34 | 8.80 | 1.79 | 16.33 | 7.12 | 36.62 |
| *Barley.* | | | | | | |
| 1. Crushed Barley, Thorp..... | 14.06 | 10.51 | 2.78 | 2.00 | 3.02 | 67.63 |
| 2. Barley Chop—T. E. Simpson | 12.60 | 9.57 | 2.22 | 2.90 | 2.49 | 70.22 |
| 3. Barley—R. Harvey......... | 12.90 | 9.63 | 2.21 | 3.58 | 1.52 | 70.16 |
| 4. Meal — Sent by M. Cohoe, | 14.48 | 5.66 | 1.84 | 4.65 | 3.05 | 70.32 |
| 5. Barley Meal.............. | 11.69 | 10.12 | 2.96 | 2.92 | 2.96 | 69.35 |
| 6. Barley Meal.............. | 10.35 | 12.16 | 3.51 | 1.93 | 2.14 | 69.91 |
| 7. Barley Meal.............. | 8.73 | 13.62 | 2.27 | 2.58 | 2.29 | 70.51 |
| 8. Barley Meal.............. | 10.43 | 9.54 | 2.25 | 2.98 | 1.58 | 73.22 |
| 9. Barley Meal.............. | 11.69 | 11.25 | 2.83 | 2.79 | 1.79 | 69.65 |
| Average................ | 11.88 | 10.23 | 2.54 | 2.92 | 2.32 | 70.11 |
| *Dried Molasses Beet Pulp.* | | | | | | |
| No. 1 Dresden................ | 8.81 | 2.71 | 1.46 | 14.14 | 6.34 | 66.54 |
| No. 2 Dresden................ | 9.03 | 2.56 | 1.53 | 12.29 | 5.93 | 68.66 |
| No. 3 Dresden................ | 8.50 | 2.95 | 1.21 | 14.43 | 7.07 | 65.84 |
| No. 4........................ | 8.35 | 3.40 | 1.00 | 13.60 | 6.44 | 67.21 |
| No. 5........................ | 9.17 | 3.09 | 1.16 | 16.21 | 6.81 | 63.56 |
| No. 6........................ | 8.22 | 2.69 | 0.89 | 15.43 | 5.99 | 66.78 |
| *No. 7 Dresden .............. | 7.69 | 3.17 | 0.73 | 20.07 | 6.03 | 62.31 |
| Average................ | 8.54 | 2.94 | 1.14 | 15.17 | 6.37 | 65.84 |
| *Stock Food.* | | | | | | |
| 1. Molassine, air-dried......... | 9.63 | 3.46 | 0.13 | 11.28 | 10.26 | 65.24 |
| 2. Biddy's Calf Food.......... | 13.82 | 11.79 | 9.21 | 03.23 | 4.59 | 57.36 |
| 3. Calf Meal—Meyer's Mill Co. | 12.57 | 4.53 | 4.54 | 13.62 | 3.75 | 60.99 |
| 4. Pratt's Animal Regulator ... | 9.18 | 8.09 | 4.38 | 03.97 | 10.28 | 64.10 |
| 5. Molasses Cattle Food....... | 8.81 | 2.71 | 1.46 | 14.14 | 6.34 | 66.54 |
| 6. Molasses Cattle Food ...... | 7.69 | 3.17 | 0.73 | 20.07 | 6.03 | 62.31 |

*Sample No. 7 contains no molasses

Only two samples of malt sprouts were analysed. These show an average of 29.34 per cent. of protein. As will be noticed these two samples are practically the same in composition. It must not be inferred however, that the composition of this feeding-stuff does not vary. As a matter of fact there is a very noticeable difference in the composition of sprouts from any two breweries. Moreover, the samples from one plant frequently differ among themselves as much as the averages from different plants.

### Barley.

Three of the samples analsyed were obtained from a manufacturer, and six from dealers.

Barley fed alone is considered somewhat "heating," and if fed continuously is likely to cause skin troubles. When combined with other grains, however, such as oats, peas, and so forth, it gives good results. The table of analysis shows that the digestibile protein is lower in barley than in oats and considerably higher than in corn. The carbohydrates, on the other hand, exceed those of the oats and fall below those in corn. Barley has also less oil than either of the two grains mentioned. When mixed with oats and ground previous to feeding, it is considered an excellent constituent of a ration for dairy cows. Some authorities claim that it has an influence on the quantity of the milk and butter. The impression appears to be prevalent among certain farmers of the Province that barley fed alone is poisonous. This statement will be given little credence by the majority of those who have had any experience in feeding the grain. It is true, as before stated, that barley is considered somewhat heating and may produce skin trouble, but that it is a poison is certainly not the case. The experience of prominent feeders, both in England and the United States, and in Europe "(it is used extensively in the latter place for the producton of pork)" wlll allow us to regard barley meal as a very valuable component of a ration for farm animals.

### Dried Molasses Beet Pulp.

This feeding-stuff consists of dried molasses and the pulp which remains as a residue from the manufacture of sugar from sugar beets. We have conducted a series of digestion experiments with this material and find it to be good feed for parties who do not have sufficient coarse feed for their stock; but beet pulp, like the coarse feeds of the farm should be supplemented by materials rich in protein. The writer is inclined to believe that the price asked for this material at the factory is altogether too high, and when the price is increased by the cost of transportation for long distance, the expense is certain to greatly over balance the gains. Whether, therefore, it will prove to be an economical feed depends upon the price asked for it and the cost of the coarser home grown feeding stuffs. Beet pulp must be regarded purely as a substitute for the coarse fodders of the farm, and should be fed with caution to young stock.

## Stock Food.

Several samples of what are usually termed "stock food" have been examined. A glance at the above table will show that in some there is a very fair quantity of protein and fat, but it must be remembered that the cost of the nutritive components of foods when purchased in such form is much in advance of their real value. Moreover, the claims that by the use of condiments and spices the digestibility of other components of the ration can be increased and in this way a saving of food can be effected, have no basis in fact. As foods, pure and simple, therefore, the prices paid for stock foods are ridiculously high when compared with the price paid for some of our most expensive standard foods.

Another important point is the ash. As was pointed out the quantity of ash in a food for young and growing animals is very important. The ash of most of our home grown foods and the ash of many of the by-products of our mills furnish a very fair amount of bone forming material. A glance at the above figures shows that all of the stock foods examined contain very large quantities of ash. In most cases, however, the ash of condimental foods contains considerable quantities of potassium salts, which tax the excretory organs of the animal and are, therefore, a decided detriment.

Another claim made by dealers in stock food is that such foods are of a medicinal or stimulating nature, and are claimed to be particularly effective and valuable, not only for growing animals, but also for cows in milk and for horses. This claim, however, should carry very little weight with the intelligent feeder, since it is a well established fact that healthy animals need no medicine or stimulant.

The writer does not mean to insinuate that stock foods should not be used under any circumstances. On the contrary, we believe that they have their places. For example, feeders who are fitting their stock for the show have successfully used stock foods. Their place, therefore, appears to be in a ration for show animals, but probably it would be better to use such foods only in the last stages of the fitting process.

It is claimed by certain prominent feeders that a better bloom can be obtained by the use of small, and limited quantities of some stock food in the last stages of feeding. It must be remembered, however, that such feeders do not consider the cost of a feeding-stuff, and in such cases as these in which the cost of the food can be overlooked, stock foods may be used.

The following shows the composition of two substances from which it was proposed to manufacture a stock food. Readers will be struck at once with the comparatively small quantity of nutritive material which such a mixture would contain. As stated before, the claims that such foods increase the digestibility of other fodders have no basis in fact. Furthermore, the purchaser of stock foods is frequently assured that the secretion of the digestive fluids is very greatly increased by the use of certain condiments. That such, in certain instances, may be the case we have no doubt, but the price paid for these foods is likely to be far in advance of the gain.

| Foods Analyzed. | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbo-hydrates. |
|---|---|---|---|---|---|---|
| *Stock Food Ingredients.* | | | | | | |
| Sphagnum Moss............... | 3.33 | 12.92 | 1.21 | 49.23 | 1.45 | 31.86 |
| Beet Sugar Molasses........... | 10.87 | 22.31 | ........ | ........ | 10.63 | 56.19 |
| *Poultry Feeds* | | | | | | |
| Western Poultry Food Co.... | 40.34 | 4.18 | 6.59 | 1.90 | 17.42 | 29.57 |
| Cypher's Chick Food......... | 12.03 | 6.01 | 1.28 | 3.10 | 29.42 | 48.16 |
| Morgan's Animal Meal........ | 58.10 | 7.59 | 21.25 | 1.34 | 12.60 | 0.0 |
| Sutherland's Seeds............ | 9.73 | 3.84 | 3.67 | 15.39 | 4.79 | 62.58 |
| Spratt's Chick Meal........... | 24.41 | 3.92 | 5.73 | 1.81 | 5.80 | 58.33 |
| Spratt's Feed for large fowl... | 19.32 | 4.76 | 5.07 | 1.09 | 16.23 | 53.52 |
| Pratt's Chick Food ........... | 15.19 | 8.31 | 7.18 | 7.51 | 7.02 | 54.79 |

## Poultry Feeds.

The above table gives the average composition of seven distinct brands of poultry foods. These feeds are composed of the usual materials known to be of value in the feeding of poultry. Some of our recognized authorities on poultry feeding tell us that they believe it would be greater economy to purchase the ingredients of these foods separately. Other poultrymen, however, think they would rather pay the difference for the convenience of having a ready mixed poultry ration whereby they avoid the storing and subsequent care of a number of materials which are of limited use in the small quantities they would have to buy.

## SUMMARY.

Only a few cases of actual adulteration have been found among the samples examined. In every instance the adulterated sample was forwarded to us by a feeder of live stock.

A considerable number of by-products, such as corn bran, oat hulls, and oat feed, etc., are of such inferior quality that they cannot, as a rule, be used to any profit.

An examination of the analyses of the feeds given in the foregoing tables, when considered in connection with the prices paid for these food materials will assist the purchaser in deciding which of the by-products is the most economical for his purpose.

At the present time the prices asked for cattle foods bear very little relation to their feeding value. That is, feed is retailed at so much per ton whether it is rich in protein and well suited to supplement our ordinary farm foods, or whether it is a starchy food, and, therefore, of much less value in compounding suitable rations for cattle. Such being the case, special care in the purchase of feeds and some knowledge of their chemical composition will be found of paramount importance in keeping the cost of feeding down to a point which will admit of a profit.

TABLE SHOWING AVERAGE COMPOSITION OF FOODS ANALYZED.

| Foods. | | Crude Protein. | Moisture. | Ether Extract. | Crude Fibre. | Ash. | Soluble Carbohydrates |
|---|---|---|---|---|---|---|---|
| Pea meal, | 8 analyses | 23.27 | 10.34 | 1.90 | 7.04 | 2.83 | 54.62 |
| Pea hulls, | 13 " | 10.04 | 7.51 | 1.44 | 42.07 | 2.92 | 36.01 |
| Mixed grain or chop, | 21 " | 12.81 | 11.27 | 4.61 | 11.00 | 3.96 | 56.35 |
| Wheat middlings, | 21 " | 15.54 | 10.10 | 3.92 | 4.26 | 3.72 | 62.46 |
| Wheat bran, | 10 " | 14.99 | 10.40 | 3.74 | 8.74 | 5.14 | 56.99 |
| Low grade flour. | 3 " | 11.94 | 11.02 | 3.58 | 0.44 | 1.88 | 71.13 |
| Shorts, | 4 " | 16.01 | 9.38 | 4.46 | 4.52 | 4.37 | 61.26 |
| Beeswing, | 3 " | 9.60 | 6.93 | 0.41 | 18.19 | 2.29 | 62.58 |
| Cotton seed meal, | 5 " | 44.18 | 5.94 | 13.65 | 4.78 | 6.91 | 24.54 |
| Cotton seed hulls, | 4 " | 4.45 | 9.73 | 1.31 | 46.60 | 2.16 | 35.75 |
| Oil cake, | 13 " | 30.41 | 9.06 | 7.07 | 10.64 | 5.89 | 36.93 |
| Gluten meal, | 22 " | 24.96 | 7.12 | 8.54 | 3.70 | 0.83 | 54.85 |
| Gluten feed, | 17 " | 25.65 | 8.61 | 7.52 | 5.92 | 0.82 | 51.47 |
| Corn chop, | 10 " | 9.36 | 9.80 | 4.47 | 1.93 | 1.40 | 73.04 |
| Corn bran, | 5 " | 8.64 | 5.97 | 2.02 | 16.27 | 2.20 | 65.90 |
| Corn ensilage, | 7 " | 10.52 | 9.26 | 2.25 | 32.64 | 6.16 | 39.17 |
| Green corn and silage, | 9 " | 9.26 | ........ | 2.34 | 30.85 | 6.44 | 51.02 |
| Oat bran, | 11 " | 6.74 | 8.07 | 1.16 | 29.38 | 4.90 | 49.75 |
| Oat dust, | 23 " | 11.93 | 9.75 | 4.76 | 12.82 | 4.15 | 56.58 |
| Oat siftings, | 5 " | 14.33 | 10.37 | 3.36 | 18.36 | 2.19 | 51.39 |
| Mill feed, | 12 " | 7.60 | 9.91 | 2.30 | 21.00 | 6.15 | 53.04 |
| Barley dust, | 11 " | 14.00 | 10.62 | 2.20 | 13.93 | 3.39 | 55.86 |
| Malt sprouts, | 2 " | 29.34 | 8.80 | 1.79 | 16.33 | 7.12 | 36.62 |
| Crushed barley, | 10 " | 11.88 | 10.23 | 2.54 | 2.92 | 2.32 | 70.11 |
| Dried beet pulp, | 7 " | 8.54 | 2.94 | 1.14 | 15.17 | 6.37 | 65.84 |

The above table shows the average composition of the samples of feeding-stuffs analysed in our laboratory. We have discussed each table separately, and, where possible, have emphasized points of difference, etc., which we consider of greatest practical value to the feeder of live stock. As mentioned in the introduction, the percentage of protein in a food is invariably considered of prime importance because our home grown crops are more likely to be deficient in this than in any other component. In selecting a food, therefore, we should aim at obtaining the greatest amount of protein for our money. There are certain serious objections, however, to some of our feeding-stuffs which contain a very large quantity of protein. Cotton seed meal, for example, contains, on an average 44.18 per cent. of protein, but many of our best feeders do not consider it a safe food to place on the hands of hired men. Many cases of milk fever and other diseases in dairy herds have been attributed to indiscriminate use of cotton seed meal. This food may be fed to advantage if care is observed as to the amount fed per day, the age of the animal, etc. All things considered, it might be wiser to make up any deficiency in protein in a ration by feeding another of the by-products mentioned (linseed meal for example). The addition of cotton seed meal to a ration for calves or pigs results in serious derangement of the digestive organs of these animals.

Pea meal, linseed meal, maize gluten, gluten feed, middlings, and wheat bran are by-products which contain a large quantity of protein, and are, therefore, most valuable components for a ration intended for dairy cows. For fattening pigs, good results have been obtained from a mixture of skim milk and low grade flour. Shorts is an excellent food for young pigs. Oat dust and other feeds of like composition, if pure, furnish nutritive materials at economical prices. The purchaser must, however, be on his guard, as frequently feeds are presented for sale on our markets which are heavily adulterated with foreign material of little value. Only to-day a sample of what was supposed to be wheat bran was sent to our laboratory. Upon examination we found this sample to be adulterated with large quantities of finely ground barley bran. From the result of our investigation, however, we are convinced that goods obtained from the local manufacturers are usually of good quality. In some instances we have found the nutritive materials, especially protein, present in smaller quantities than we might have expected, but in most cases this deficiency was due, not to adulteration, but to the poor quality of the grain from which the by-product was obtained.

Regarding mill feed, oat hulls and such low grade materials little need be said. The tables of composition show them to be entirely unfit to feed as substitutes for pea meal, linseed cake, and such nitrogenous materials. There are cases, however, in which these feeding-stuffs might be used to advantage, but the feeder is likely to be misled in the purchase of these materials, because the price asked, judged from the cost of standard food materials would indicate value which they do not possess. Economical purchase, however, does not imply the purchase of the lowest priced foods. As previously observed many of the waste products of our mills are not altogether worthless, but it is important that purchasers should know what they are and what relation they bear to the standard feeds. In some cases finely ground materials are sold under fancy names and these in many instances are essentially inferior to ordinary farm roughage. Feeders of live stock should not be deceived in such a case by false claims or a fancy name, suggesting good quality or good origin. Purchasers are, therefore, advised to be on their guard in the selection of some of these so-called cheap by-products. It is safer, as a rule, to buy standard foods as their quality may be pretty accurately judged.

## APPENDIX.

As stated in the introduction, the tables giving the percentage composition of the foods analysed furnish us with information regarding the total amounts of the different constituents present in foods, but as only that portion of the food which is digested is of direct use to the animal, it has been deemed advisable to append a table giving the approximate amounts of digestible nutrients contained in the various fodders. The data upon which some of these calculations are based are taken from the results reported in Bulletin No. 77 of the U. S. Department of Agriculture. The digestibility of a number of these feeding-stuffs under consideration has been determined at this Station, and in such cases we have used our own data in calculating the amounts of digestible nutrients.

As will be seen from the following table, the digestibility of the different foods varies markedly, and it must also be remembered that the digestibility of some foods varies under different conditions. Furthermore, in those foods which are marked thus * the digestibile components have been calculated from the digestibility of American feeding stuffs of the same name, and the digestion co-efficients of these may vary quite widely from our own. Therefore, when using the figures which are given in the following table, the feeder must bear in mind that he is dealing with approximate quantities only.

The importance of the supply of protein in a ration has been sufficiently emphasized to require no further mention. It may be stated, however, that if an excess of the amount required to build up and repair the waste of the body be fed the protein may be converted into fat and deposited as such or used to produce heat and energy. For these purposes it is about as efficient as the carbohydrates, but it is far more expensive than the latter, and, therefore, only as much should be supplied to the mature animal as will be used in repairing the necessary breaking down of the nitrogenous tissues in the animal body. In the case of growing animals and such animals as are kept for the production of milk, wool, and so forth, an increased amount of protein in the food is necessary.

The matter of computing rations for the various kinds of animals raised on the farm is, therefore, an important one to the feeder, for since the protein, on the one hand, and the carbohydrates on the other, serve in the main different purposes in the animal economy, it is evident that relative amounts of these nutrients in the food should be considered. This relation is called the nutritive ratio, which means simply the relation of the digestible protein to the digestible carbohydrates and fat, the fat having been multiplied by 2.25 before adding it to the carbohydrates. The nutritive ratio is then found by dividing the carbohydrates plus 2.25 times the fat by the protein. In the following table the sum of the carbohydrates and fat thus obtained is given in the third column, which divided by the protein, as given in the second column, gives us the nutritive ratio of the food.

## DIGESTIBLE NUTRIENTS IN STATED AMOUNTS OF FOOD STUFFS.

| Kind and Amount of Food. | | Total dry Matter. | Pounds of Digestible Nutrients. Protein | Carbohydrates + (Fat X 2.25) | Total | Nutritive Ratio. |
|---|---|---|---|---|---|---|
| *Pea Meal............. | 1 pound | .896 | .193 | .543 | .736 | 1:2.8 |
| | 2 " | 1.792 | .386 | 1.086 | 1.472 | |
| | 3 " | 2.688 | .579 | 1.629 | 2.208 | |
| | 4 " | 3.584 | .772 | 2.172 | 2.944 | |
| | 5 " | 4.480 | .965 | 2.715 | 3.680 | |
| †Pea Hulls............ | 1 " | .924 | .073 | .440 | .513 | 1:6.03 |
| | 2 " | 1.848 | .146 | .880 | 1.026 | |
| | 3 " | 2.772 | .219 | 1.320 | 1.539 | |
| | 4 " | 3.696 | .292 | 1.760 | 2.052 | |
| | 5 " | 4.620 | .355 | 2.200 | 2.565 | |
| | 6 " | 5.544 | .438 | 2.640 | 3.078 | |
| | 7 " | 6.468 | .511 | 3.080 | 3.591 | |
| | 8 " | 7.392 | .584 | 3.520 | 4.104 | |
| | 9 " | 8.316 | .657 | 3.960 | 4.617 | |
| †Mixed Grain or Chop .. | 1 " | .887 | .102 | .573 | .675 | 1:5.6 |
| | 2 " | 1.774 | .204 | 1.146 | 1.350 | |
| | 3 " | 2.661 | .306 | 1.719 | 2.025 | |
| | 4 " | 3.548 | .408 | 2.292 | 2.700 | |
| | 5 " | 4.435 | .510 | 2.865 | 3.375 | |
| | 6 " | 5.322 | .612 | 3.438 | 4.050 | |
| | 7 " | 6.209 | .714 | 4.011 | 4.725 | |
| | 8 " | 7.096 | .816 | 4.584 | 5.400 | |
| | 9 " | 7.983 | .918 | 5.157 | 6.075 | |
| | 10 " | 8.870 | 1.020 | 5.730 | 6.750 | |
| *Wheat Middlings...... | 1 " | .899 | .124 | .590 | .714 | 1:4.76 |
| | 2 " | 1.798 | .248 | 1.180 | 1.428 | |
| | 3 " | 2.697 | .372 | 1.770 | 2.142 | |
| | 4 " | 3.596 | .596 | 2.360 | 2.856 | |
| | 5 " | 4.495 | .620 | 2.950 | 3.570 | |
| †Wheat Bran........... | 1 " | .896 | .116 | .463 | .579 | 1:3.99 |
| | 2 " | 1.792 | .232 | .926 | 1.158 | |
| | 3 " | 2.688 | .348 | 1.389 | 1.737 | |
| | 4 " | 3.584 | .464 | 1.852 | 2.316 | |
| | 5 " | 4.480 | .580 | 2.315 | 2.895 | |
| | 6 " | 5.376 | .696 | 2.778 | 3.474 | |
| | 7 " | 6.272 | .812 | 3.241 | 4.053 | |
| | 8 " | 7.168 | .928 | 3.704 | 4.632 | |
| †Low Grade Flour...... | 1 " | .889 | .090 | .600 | .690 | 1:6.67 |
| | 2 " | 1.778 | .180 | 1.200 | 1.380 | |
| | 3 " | 2.667 | .270 | 1.800 | 2.070 | |
| | 4 " | 3.556 | 3.60 | 2.400 | 2.760 | |
| | 5 " | 4.445 | 4.50 | 3.000 | 3.450 | |

| Kind and Amount of Food. | | | Total Dry Matter | Pounds of Digestible Nutrients. | | | Nutritive Ratio |
|---|---|---|---|---|---|---|---|
| | | | | Protein | Carbohydrates + (Fat X 2.25) | Total | |
| *Shorts ................ | 1 | " | .906 | .117 | .614 | .731 | 1:5.25 |
| | 2 | " | 1.812 | .234 | 1.228 | 1.462 | |
| | 3 | " | 2.718 | .351 | 1.842 | 2.193 | |
| | 4 | " | 3.624 | .468 | 2.456 | 2.924 | |
| | 5 | " | 4.530 | .585 | 3.070 | 3.655 | |
| | 6 | " | 5.436 | .702 | 3.684 | 4.386 | |
| | 7 | " | 6.342 | .819 | 4.298 | 5.117 | |
| | 8 | " | 7.248 | .936 | 4.912 | 5.848 | |
| †Beeswing ............ | 1 | " | .93 | .072 | .503 | .520 | 1:6.9 |
| | 2 | " | 1.86 | .144 | 1.006 | 1.040 | |
| | 3 | " | 2.79 | .216 | 1.509 | 1.560 | |
| | 4 | " | 3.72 | .288 | 2.012 | 2.080 | |
| | 5 | " | 4.65 | .360 | 2.515 | 2.600 | |
| | 6 | " | 5.58 | .432 | 3.018 | 3.120 | |
| | 7 | " | 6.51 | .504 | 3.521 | 3.640 | |
| | 8 | " | 7.44 | .576 | 4.024 | 4.160 | |
| | 9 | " | 8.37 | .648 | 4.527 | 4.680 | |
| | 10 | " | 9.30 | .720 | 5.030 | 5.200 | |
| *Cotton Seed Meal...... | 1 | " | .94 | .390 | .448 | .838 | 1:1.15 |
| | 2 | " | 1.88 | .780 | .896 | 1.676 | |
| | 3 | " | 2.82 | 1.170 | 1.344 | 2.514 | |
| | 4 | " | 3.76 | 1.560 | 1.792 | 3.352 | |
| | 5 | " | 4.70 | 1.950 | 2.240 | 4.190 | |
| | 6 | " | 5.64 | 2.340 | 2.688 | 5.028 | |
| *Cotton Seed Hulls...... | 1 | " | .902 | .006 | .265 | .271 | 1:44.16 |
| | 2 | " | 1.804 | .012 | .530 | .542 | |
| | 3 | " | 2.706 | .018 | .795 | .813 | |
| | 4 | " | 3.608 | .024 | 1.060 | 1.084 | |
| *Oil Cake .............. | 1 | " | .909 | .259 | .497 | .756 | 1:1.9 |
| | 2 | " | 1.818 | .518 | .994 | 1.512 | |
| | 3 | " | 2.727 | .777 | 1.491 | 2 278 | |
| | 4 | " | 3.636 | 1.036 | 1.988 | 3.024 | |
| | 5 | " | 4.545 | 1.295 | 2.485 | 3.780 | |
| | 6 | " | 5.454 | 1.554 | 2.962 | 4.536 | |
| *Gluten Meal........... | 1 | " | .929 | .220 | .513 | .733 | 1:2.3 |
| | 2 | " | 1.858 | .440 | 1.026 | 1.466 | |
| | 3 | " | 2.787 | .660 | 1.539 | 2.199 | |
| | 4 | " | 3.716 | .880 | 2.052 | 2.932 | |
| | 5 | " | 4.645 | 1.100 | 2.565 | 3.665 | |
| | 6 | " | 5.574 | 1.320 | 3.078 | 4.398 | |
| | 7 | " | 6.503 | 1.540 | 3.591 | 5.131 | |
| | 8 | " | 7.432 | 1.760 | 4.104 | 5.864 | |

| Kind and Amount of Food. | | Total Dry Matter | Pounds of Digestible Nutrients. | | | Nutritive Ratio |
|---|---|---|---|---|---|---|
| | | | Protein | Carbohydrates + (Fat X 2. 25) | Total | |
| *Gluten Feed........... | 1 " | .913 | .219 | .625 | .844 | 1: 2.8 |
| | 2 " | 1.826 | .438 | 1.250 | 1.688 | |
| | 3 " | 2.739 | .657 | 1.875 | 2.532 | |
| | 4 " | 3.652 | .876 | 2.500 | 3.376 | |
| | 5 " | 4.565 | 1.095 | 3.125 | 4.220 | |
| | 6 " | 5.478 | 1.314 | 3.750 | 5.064 | |
| | 7 " | 6.397 | 1.533 | 4.375 | 5.908 | |
| | 8 " | 7.304 | 1.752 | 5.000 | 6.752 | |
| *Corn Chop............. | 1 " | .902 | .063 | .783 | .846 | 1: 12.4 |
| | 2 " | 1.804 | .126 | 1.566 | 1.692 | |
| | 3 " | 2.706 | .189 | 2.349 | 2.538 | |
| | 4 " | 3.608 | .252 | 3.132 | 3.384 | |
| | 5 " | 4.510 | .315 | 3.915 | 4.230 | |
| | 6 " | 5.412 | .378 | 4.398 | 5.076 | |
| | 7 " | 6.314 | .441 | 5.481 | 5.922 | |
| | 8 " | 7.216 | .504 | 6.264 | 6.768 | |
| †Corn Bran ............ | 1 " | .94 | .053 | .413 | .466 | 1: 7.8 |
| | 2 " | 1.88 | .106 | .826 | .932 | |
| | 3 " | 2.82 | .159 | 1.239 | 1.398 | |
| | 4 " | 3.76 | .212 | 1.652 | 1.864 | |
| | 5 " | 4.70 | .265 | 2.065 | 2.330 | |
| †Corn Ensilage ......... | 1 " | .21 | .055 | .451 | .506 | 1: 8.2 |
| | 5 " | 1.05 | .275 | 2.255 | 2.530 | |
| | 12 " | 2.52 | .660 | 5.412 | 6.072 | |
| | 15 " | 3.15 | .825 | 6.765 | 7.590 | |
| | 18 " | 3.78 | .990 | 8.118 | 9.108 | |
| | 20 " | 4.20 | 1.000 | 9.020 | 10.120 | |
| †Oat Dust .............. | 1 " | .902 | .081 | .434 | .515 | 1: 5.35 |
| | 2 " | 1.084 | .162 | .868 | 1.030 | |
| | 3 " | 2.706 | .243 | 1.302 | 1.545 | |
| | 4 " | 3.608 | .324 | 1.736 | 2.060 | |
| | 5 " | 4.510 | .405 | 2.170 | 2.575 | |
| | 6 " | 5.412 | .486 | 2.604 | 3.090 | |
| | 7 " | 6.314 | .567 | 3.038 | 3.605 | |
| | 8 " | 7.216 | .648 | 3.472 | 4.120 | |
| *Malt Sprouts .......... | 1 " | .912 | .235 | .316 | .551 | 1: 1.3 |
| | 2 " | 1.824 | .470 | .632 | 1.102 | |
| | 3 " | 2.736 | .705 | .948 | 1.653 | |
| | 4 " | 3.648 | .940 | 1.264 | 2.204 | |
| | 5 " | 4.560 | 1.175 | 1.580 | 2.755 | |
| | 6 " | 5.472 | 1.310 | 1.896 | 2.306 | |
| | 7 " | 6.384 | 1.645 | 2.212 | 3.857 | |
| | 8 " | 7.296 | 1.880 | 2.528 | 4.408 | |
| | 9 " | 8.208 | 2.115 | 2.844 | 4.959 | |
| | 10 " | 9.120 | 2.350 | 3.160 | 5.510 | |

| Kind and Amount of Food. | | Total Dry Matter. | Pounds of Digestible Nutrients. Protein | Carbohydrates + (Fat X 2.25) | Total | Nutritive Ratio |
|---|---|---|---|---|---|---|
| *Crushed Barley ....... | 1 " | .897 | .096 | .646 | .742 | 1: 6.73 |
| | 2 " | 1.794 | .192 | 1.292 | 1.484 | |
| | 3 " | 2.691 | .288 | 1.938 | 2.226 | |
| | 4 " | 3.588 | .384 | 2.584 | 2.968 | |
| | 5 " | 4.485 | .480 | 3.230 | 3.710 | |
| | 6 " | 5.382 | .576 | 3.876 | 4.452 | |
| †Dried Beet Pulp....... | 1 " | .970 | .072 | .655 | .727 | 1: 9.09 |
| | 2 " | 1.940 | .144 | 1.310 | 1.454 | |
| | 3 " | 2.910 | .216 | 1.965 | 2.181 | |
| | 4 " | 3.880 | .288 | 2.620 | 2.908 | |
| | 5 " | 4.850 | .360 | 3.275 | 3.635 | |
| | 6 " | 5.820 | .432 | 3.930 | 4.362 | |
| | 7 " | 6.790 | .504 | 4.585 | 5.089 | |
| | 8 " | 7.760 | .576 | 5.240 | 5.816 | |
| | 9 " | 8.730 | .648 | 5.895 | 6.543 | |
| | 10 " | 9.700 | .720 | 6.550 | 7.270 | |

* Results calculated from American records.

† Digestibility of foods marked thus was determined at this Station. Work along this line is in progress, and we expect soon to have sufficient data for a bulletin dealing more particularly with the question of digestion co-efficients.

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| Serial No. | Date. | | Title. | Author. |
|---|---|---|---|---|
| 106 | June | 1897 | The San Jose Scale | J. H. Panton. |
| 107 | May | 1898 | Diary Bulletin (out of print, see No. 114) | Dairy School. |
| 108 | Aug. | 1898 | Experiments with Winter Wheat | C. A. Zavitz. |
| 109 | Sept. | 1898 | Farmyard Manure | G. E. Day. |
| 110 | Jan. | 1900 | Experiments in Feeding Live Stock (out of print) | G. E. Day. |
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| 138 | Feb. | 1905 | The Composition of Ontario Feeding Stuffs | W. P. Gamble. |

ONTARIO AGRICULTURAL COLLEGE.

# BULLETIN 139.

# An Experimental Shipment of Fruit to Winnipeg.

By J. B. REYNOLDS, B.A.,
Professor of Physics.

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## PREFATORY NOTE.

The writer desires to acknowledge his indebtedness to those who, by suggestions offered, and assistance given, contributed to the success of this most important experiment: to Mr. P. W. Hodgetts, of the Department of Agriculture, Toronto, who assisted in various ways at the shipping point; to Mr. P. J. Carey, Dominion Fruit Inspector, who officially examined every lot of fruit offered, and by his kindly, tactful manner, no less than by his expert knowledge, made his services invaluable; and to Professor H. L. Hutt, Horticulturist, Ontario Agricultural College, who from time to time gave freely suggestions respecting the varieties of fruit best to ship, who examined and reported upon the fruit at the shipping point, and who prepared one section of this Bulletin, "Observations at the Shipping Point." To all of these gentlemen, and to many others, acknowledgement of services rendered is herewith made.

J. B. REYNOLDS.

*Ontario Agricultural College and Experimental Farm.*

# AN EXPERIMENTAL SHIPMENT OF FRUIT TO WINNIPEG.

By J. B. Reynolds, Professor of Physics.

## SUMMARY.


1. The Western market demands well-colored and well-matured fruit.
2. Both in appearance and in prices, Ontario peaches, if allowed to mature properly on the tree, compare favorably with California peaches on the Winnipeg market.
3. California and British Columbia, although at a much greater distance than Ontario, are fast getting a monopoly of the Western market.
4. Owing to tariff and higher freight charges, California peaches, in competition with Ontario peaches, suffer a handicap of 40 cents a box.
5. In carload lots, freight rates to Winnipeg, including icing, are little more than one-third express rates. Quickly-ripening fruit is safer in a good refrigerator car for six or eight days than in a hot unventilated express car for three days.
6. Transportation ought to be no hindrance to a large expansion of trade in tender fruits between Ontario and the Northwest. Peaches, plums, grapes, and Bartlett pears, well matured, carried safely with eight days' transit. A transit of five days over the same route is frequently accomplished, and is quite practicable.
7. Our fruit is at a disadvantage in the market because of the general lack of uniformity, neatness, and skill displayed in grading and packing.
8. A uniform size and style of package is very desirable. So far as possible, all box packages should be of the same length and width, and should vary in depth to suit the character of the fruit.
9. So far as rapid cooling and safe shipping in cold storage are concerned, the barrel is suited to winter apples, the bushel box, 10x11x20 inches, to early fall apples and winter pears, and the half bushel 5x11x20 inches, to peaches and early pears.
10. The basket carries grapes and plums satisfactorily, but, for safety, it should be enclosed, as in the Georgia 5-basket carrier, Fig. 4, or the 2-basket carrier, Fig. 8.
11. To remedy existing defects in all departments of the fruit trade, and to put it on a secure footing, the co-operative plan should be adopted, including a central packing house, the employment of expert packers, and an organization capable of overcoming obstacles.

## I. PRELIMINARY ARRANGEMENTS.

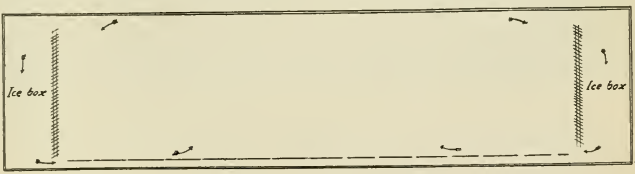
(1). In the summer of 1903 the writer, after making some extended inquiries into the matter of transportation of fruit under refrigeration, recommended to the Minister of Agriculture an experimental shipment of fruit from Southern Ontario to the Northwest of Canada, with a view to obtaining information on the whole question of the Western fruit trade. The situation with respect to this trade, though it should be full of hope, is as a matter of fact discouraging to the Ontario fruit-grower. On the one hand, as an enticing prospect, there lies the great Northwest, a large, increasing, and ever profitable market. The choice fruits peculiar to Southern Ontario will never be produced in those northern latitudes, and an exchange of Ontario fruits for No. 1 hard wheat seems reasonable and proper. On the other hand, as a discouraging reality, fruits from the Pacific Coast are rapidly pre-empting the Western market, and rarely can Ontario peaches, grapes, and plums be seen displayed in the shop-fronts of Winnipeg. Very little fruit, if any, except apples and pears, is being shipped to the West by freight, and express charges are almost prohibitive. Prominent and well informed fruit growers, who have done some shipping on their own account, upon being consulted on this matter, gave the opinion that, for several reasons, a freight traffic in tender fruits between Ontario and the Northwest was impracticable. The reasons given are, in the main as follows : First, our fruits are not of good shipping quality; secondly, the railroads do not give sufficiently rapid despatch; thirdly, in refrigerator cars, icing is not properly attended to in transit; fourthly, the market, and the means of disposing of the fruit in the West, are uncertain.

With respect to the first of these objections, namely, the poor shipping quality of our tender fruits, the force of the objection remained to be tested by an actual shipping experiment. In the meantime, storage experiments conducted at the College had demonstrated that Crawford peaches will hold their form and quality for eighteen days at a temperature of 38 degrees; peaches of the Longhurst type will keep sound and firm for thirty-six days, and Washington and Bradshaw plums for twenty days, at the same temperature. It is generally supposed, however, that fruits do not keep so well during shipping as they do in the warehouse, by reason of the injuries incident to transportation. At the same time, careful packing and loading in carload lots not to be rehandled during transit, would, it was believed, reduce to a minimum the damage incurred in shipping.

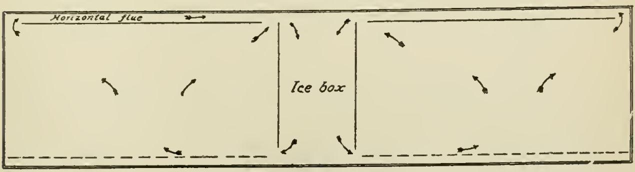
The remaining objections, namely, those relating to time of transit, icing, and the market, while undoubtedly serious, are not insurmountable, and relate to conditions capable of improvement and correction. It was the aim of the proposed experiment to secure information upon these very points, and to bring such matters as require righting to the attention of authorities competent to deal with them.

Early in the season of 1904, with the approval of the Minister, active preparations for this shipment were commenced. Much preliminary work had to be covered before the shipment could be undertaken, such as deciding upon and obtaining the packages to be used, interviewing fruit growers and securing promises of contributions to the shipment, instructing them upon the selection and packing of the fruit, and arranging the terms upon which the fruit was to be supplied. Before hand, certain conditions seemed without trial to be essential to success, and these were as far as possible closely adhered to: the fruit selected should be all No. 1 grade, and should be sufficiently mature to be of good quality upon reaching the market; peaches and Bartlett pears should be wrapped singly in paper; closed packages only should be used; the cars should be loaded carefully by nailing each package in place, and by spacing packages so as to allow circulation of air on all sides of a package; by shipping in carload lots the fruit would not be rehandled until it reached the market; and the cars must be kept iced, and as quick transit as possible secured. Crawford peaches formed the staple variety in the shipment, and as many kinds of fruit as were in season at the same time were included. Owing to the lateness of fruit this year, the cars were not shipped until September 14th and 16th respectively.

(2). From St. Catharines was sent a C. P. R. car, Bohn refrigerator system, and from Grimsby a car known as the Hanrahan refrigerator. These two cars differ in their interior construction in four particulars: First, the ice bunkers in the Bohn system are at the ends of the car; in the Hanrahan the ice is in the middle of the car; second, in the Hanrahan, horizontal flues the full width of the car run just below the ceiling from the ice bunkers in both directions to the ends of the car, for the purpose of




Section of C.P.R. car; Bohn refrigerator.




Section of a Hanrahan car.
Fig. 1.

conveying to the bunkers the warm air from the ends remote from the ice and allowing cold air to flow back to these ends; in the Bohn system there is no such flue. Third, the floor of the Hanrahan is provided with a rack, like lattice work, that carries the load off the floor and allows air to flow underneath; the floor of the Bohn system is provided only with slats two inches high and about eight inches apart running lengthwise of the car. These slats are not suitable for loading boxes. The fourth difference consists in the form of partition between the ice bunker and the car proper. In both cases there are spaces above and below the partition providing for the flow of warm and cold air. But in the Hanrahan the partition, with the exception of these spaces, is solid, and thus gives definite direction to the air currents. In the Bohn system the partition is formed of galvanized iron slats, placed like the slats in a window shutter. Sections of the cars are shown in Fig. 1, and illustrate these differences.

It was expected that a transit of six or eight days with plums and Crawford peaches would indicate any difference in efficiency between these cars. It is claimed that some refrigerator cars fail to maintain a uniform temperature throughout the car—the top of the car and the parts most remote from the ice, being, it is claimed, several degrees higher in temperature than the bottom near the ice. This difference of temperature would of course be most pronounced in hot weather, and in cool weather would be small. It so happened that the weather during this shipment was quite cool. Whether or not this fact accounts for the uniformity in results cannot be asserted, but at all events there was no noticeable difference in the condition of the fruit upon arrival at Winnipeg. As a test of efficiency in the cars, therefore, the experiment is inconclusive, and must be repeated in warmer weather or over greater distances, before any decisive report can be given out upon this matter.

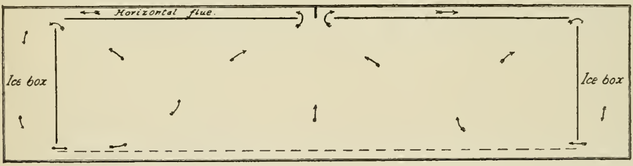



Fig. 2.—Section of car showing interior construction for air circulation with bunkers at end. The solid partition next to the ice and the horizontal flue overhead will, it is believed, improve the efficiency of refrigerator cars.

To maintain uniformity of temperature throughout a refrigerator it has been already demonstrated beyond question that a regular circulation of air through the whole system, including refrigerator and ice-house, is necessary. To secure circulation the construction of the refrigerator must be such as to give direction to the air. In principle, and in practice where the test is sufficiently severe, the Bohn system may be improved by adopting the essential parts of the Hanrahan system where this relates to air circulation; that is, a solid instead of a slatted partition, and a flue overhead, (Fig. 2).

## II. OBSERVATIONS AT THE SHIPPING POINT.

By Prof. H. L. Hutt, Horticulturist, Ontario Agricultural College.

(1) The Fruit. Among the objects of this shipment, one was to place on the Winnipeg market some of the choicest fruit that Ontario could produce, in the hope of helping to open a trade for Ontario growers in the great Northwest.

The accompanying tables give in a condensed form most of the particulars regarding the class, variety, grade, and condition of the fruit shipped. While much of the fruit in each car was first-class, or graded XXX, some of it, as the records show, fell much below that grade, and certainly would not have been shipped if sufficient first-class fruit had been obtainable at the time. The growers were handicapped in this respect to some extent by the unusual lateness of the season, and also by the light crop of some classes of fruit, particularly of the peaches and plums, which we were especially desirous of including in the shipment.


Fig. 3.—Some Ontario Apple Boxes:
1. Dimensions, 9 in. x 12 ½ in. x 19 in ; capacity, 2137 cubic inches.
2. Dimensions, 9 in. x 13 in. x 18 in. ; capacity, 2106 cubic inches.
3. Dimensions, 9¾ in. x 14 in. x 20¼ in. ; capacity, 2764 cubic inches.
4. Dimensions, 10 in. x 10 in. x 22¼ in. ; capacity, 2225 cubic inches.
5. Dimensions, 11 in. x 11¼ in. x 22½ in. ; capacity, 2784 cubic inches.
The standard size (not shown), 10 in. x 11 in. x 20 in. ; capacity, 2200 cubic inches.

Another reason that much of the fruit was not of a kind to tempt the buyer was because it was picked too green. A general impression seemed to be in the minds of many of the shippers that none but green, hard fruit, particularly of peaches, plums, and pears, would carry safely to the Winnipeg market. This was, of course, a point upon which no reliable information was at hand, and one of the valuable lessons afforded by this experiment is that our finer fruit, such as peaches, plums, and pears, should at the time of shipment be well matured, well colored, and not too firm to be quite ripe, or at least mellow, by the time it is placed on the market.

The peaches in these shipments that were hard and firm when shipped reached the Winnipeg market without any perceptible change, while those that were matured enough to be semi-firm when shipped were in the best condition to attract buyers when placed on the market at Winnipeg.

One box of first-class peaches, which at the point of shipment had been recorded as "semi-firm and probably too ripe for shipment" was traced to the consumer and a special report was obtained on it. This box was packed on September 15th, loaded September 16th, and sold at Winnipeg on September 23rd. On September 26th the buyer reported that "a few of the peaches were then mellow enough to use, and by the end of the week the whole of the box would probably be sufficiently ripe."

This may seem an exceptional case, and there is no doubt that the cool weather at Winnipeg after the arrival of the shipment aided in the keeping of the fruit. Still it establishes the fact that if our finest peaches are allowed to attain full size and color before picking, and are then cooled down quickly and kept cool, they can be shipped or held at least two weeks and be in prime condition for use.

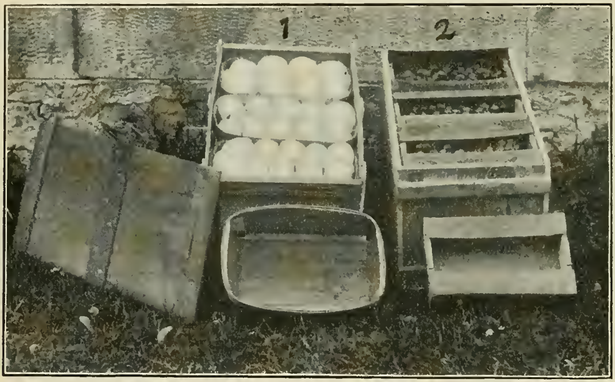



Fig. 4.—(1) The Georgia carrier for peaches or plums. (2) The standard apple box fitted with trays for grapes.

(2) Packages. Owing to the fact that there are so many kinds of packages in use for the different kinds of fruit, and that the fruit was supplied by a number of growers, there was no uniformity in the size and shape of the packages used in these shipments. For several reasons this was a decided disadvantage. They could not be packed to advantage in the car; when placed on the market they presented a motley and unattractive appearance; buyers were at a loss to know which shape of package was really the best value for the money. All this could not but injure to some extent the sale of the fruit.

It was thought best, for these shipments, to adopt the box or crate package rather than the barrel or basket. No barrels or baskets were sent except a few baskets of grapes from St. Catharines, which were placed on top after all the boxes had been loaded in the car, in which position they carried all right. It is doubtful, however, if the basket is sufficiently strong to stand the pressure when loaded from the bottom to top of the car.

For the apples, the box used was 10x11x20 inches, the size adopted as the standard by the Ontario Fruit Growers' Association. This makes a convenient shaped box for packing and handling, and if it is to be the standard size, the sooner all shippers fall in line and make use of it, the better it will be for the trade.

For the pears three different shapes of boxes were used in one car; one 5x11x20 inches, another 5x10x22½ inches, and still another 5x12x18½ inches. It can readily be understood how awkward these various sizes were to pack together in a car. The first had been adopted as the standard pear box and is just half the size of the standard apple box.

To secure uniformity in the peach packages, boxes 5x12x18½ inches, the same size as the California peach case, were furnished to those who had agreed to ship peaches. This may be a convenient size for packing peaches and pears, but a more convenient size for shipping in mixed car lots would be the standard pear box.

The grapes were shipped in the standard apple box, fitted with twelve cardboard trays, having wooden ends, each tray holding about 2½ pounds of fruit, as shown to the right in Fig. 4. This makes a very safe and convenient package, and apparently was an acceptable one in the Winnipeg market, no doubt because it rendered convenient the retailing of the fruit in small quantities. This case, however, at the present price, 30 cents, is altogether too expensive. A case after the style of the Georgia peach carrier, as shown to the left in Fig. 4, is one well worthy of adoption by our growers. This case has been adopted almost entirely for the Georgia peach trade, and is looked upon by the fruit experts at the Department of Agriculture at Washington as the best case in use for peaches, plums, and grapes This case complete, with the six 4-quart baskets, as shown, can be purchased F.O.B. Georgia at 12½ cents. Surely our manufacturers could put up such a case for at least 15 cents.

Apart from the desirability of adopting a uniform style of package. there are two other respects in which the general appearance of our packages might be improved. The lumber of which they are made should be neatly dressed, and the branding should be more uniform and neatly done. Professor Reynolds, who accompanied these cars to Winnipeg, had an opportunity of comparing our packages with those in California shipments, which arrived while he was there. In this respect he says: "The general appearance of our boxes leaves much to be desired. They are rough and unfinished. Dressing the outside of the lumber of which they are made would cost only a trifle more, and would add much to their general appearance, besides making any printing, stamping, or writing more legible." With regard to the branding he says: "The designations of the boxes, the packer's name, the variety and grade are not made sufficiently distinct, and the styles of branding are anything but uniform. The result is that it is often difficult to make out the names of the shippers or the variety or grade of the fruit; and when viewed as a whole on the market, they presented a motley and unattractive appearance."

(3) GRADING AND PACKING. The car from St. Catharines was filled with apples, pears, peaches, plums, and grapes, the fruit being furnished by eighteen of the growers of that locality. Dominion Fruit Inspector Carey and I examined carefully a number of cases of each class of fruit put up by each shipper. A large number of the growers were present, and the one fault which was evident to all was the great lack of uniformity in grading, packing and branding. Evidently no two shippers seemed to have the same idea as to what constituted No. 1 or No. 2 grade of fruit. Some of the growers sent in first-class fruit packed in first-class style, but others sent in ungraded fruit, improperly packed and wrongly branded. From my personal acquaintance with many of the shippers concerned, I feel certain that none of them would intentionally do wrong in this matter; yet the fact remains that in a trial shipment made with the object of open-

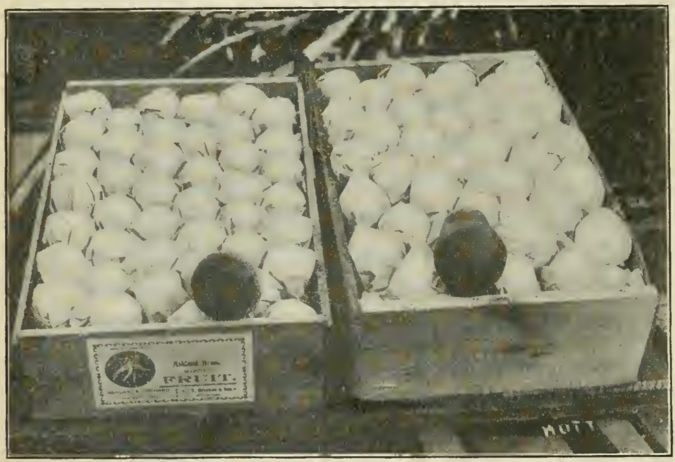



Fig. 5.—First-class peaches and pears, carefully graded and neatly packed.

ing up a new market, fruit was being sent which, because of the grading and packing, could not but bring discredit upon the shipper whose name appeared on every case, and could not but tend to close the market against even those who were doing all right, but happened to be in bad company. To avoid as much as possible such a result, we found it necessary in some cases to rebrand the fruit to a lower grade.

It so happened that there was present at the time of the shipment Mr. Carson, a Canadian, who was a few years ago engaged in fruit growing in the Georgian Bay district. He was an interested spectator, because he is now engaged in shipping California fruit to the Northwest market. He told us frankly that he had no fear of competition from Ontario so long as our fruit was sent in such condition, and, for the benefit of those present, a demonstration was given as to how the California fruit is graded and packed for shipment.

A few cases picked at random from Mr. W. H. Bunting's consignment were opened and exhibited as samples which might be depended upon to create a demand in whatever market they might be placed.

The majority of the shippers present were keen to learn and thankful for the suggestions given. One stated that the information gained from the object lesson afforded in grading and packing was well worth all the effort in getting up such a shipment.

From Grimsby the same kinds of fruit were sent, but the carload was made up by only six shippers; consequently, where there were fewer shippers each putting up from one to two hundred cases of his own, there was much more uniformity in packing; yet, even here, we found fruit packed in such a way that it could not but injure the reputation for Ontario fruit on whatever market it might be placed. It was plainly evident to those who examined the fruit that Ontario fruit-growers will have to bestir themselves if they ever expect to compete with California and British Columbia, which now have practically a monopoly on the Northwest market.

(4) Co-Operation Essential. The greatest need in this part of the business is more uniformity in grading and packing, and vigilant care that none but first-class fruit be offered for sale under a XXX brand. It appears to me that we will never satisfactorily meet these requirements so long as each grower is working alone and independent of his neighbor. What is necessary is, that in each fruit section the growers unite to form a strong co-operative association, that a good energetic man be selected as manager, and that experts be employed to grade and pack the fruit. This would probably necessitate the building of a central packing-house, and involve some expense, but the advantages to be gained would well repay for the outlay. Baskets, boxes and barrels could be purchased wholesale to better advantage; the grower could devote his whole attention to gathering the crop when in proper condition; the association would relieve him of all care and responsibility in grading, packing and marketing; and with this work in the hands of expert packers, the grade would be uniform, the packing carefully and properly done, and with a good business manager in close touch with the markets, the fruit could be marketed when and where it was most in demand. This in the end would result in increased demand on the part of the consumer and increased profits on the part of the producer.

## III. TRANSPORTATION.

(1) Loading the Car. In loading a refrigerator car with boxes of fruit, there are two conditions to be kept in view; a rigid structure, and provision for circulation of air on all sides of the boxes.

The plan in detail is illustrated in Fig. 6, which shows a number of boxes in position in the car. A row of boxes of the same length and depth was placed side by side, with ends butting against the end of the car, and separated from one another and from the sides of the car by narrow spaces. Across each end of the row a slat was laid, nailed to each box,

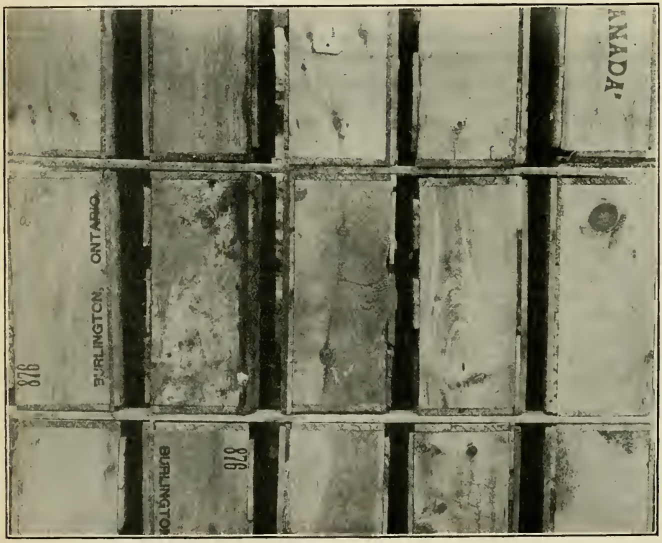



Fig. 6.

and butting against the sides of the car. This was repeated until a tier was formed as high as it was desired to go. Then another tier was built in exactly the same way, butting against the first tier, and so on from each end of the car, until it was filled. If any space remains over at the middle, too narrow for a tier of boxes, the load may be braced by scantling.

(2) Rate of Despatch. G. T. R. The St. Catharines car left that point about 6 p.m. on September 14th, and arrived at North Bay about 7 p.m. on September 16th, having accomplished a distance of 300 miles in 49 hours, at the average rate of six miles an hour. The second car left

Grimsby at about the same time of the day on September 16th and reached North Bay at about 3 p.m. on September 18th, at about the same rate of despatch. Upon his return from the West, the writer communicated these facts to the Grand Trunk Division Freight Agent, and received the rollowing reply:

Dear Sir,—Your favor of the 8th inst. was received on my return to the city this morning.

I am sorry that there has apparently been some delay to your shipments of fruit from the Niagara District to the Northwest, in so far as our transportation service from shipping points to North Bay is concerned. I am taking matter up with our Car Service Agent with a view of seeing if a more satisfactory schedule can be arranged, and will advise you as soon as I receive his reply.

Yours truly,

C. E. Dewey.

C. P. R. The first car left North Bay at 2 p.m. on Saturday the 17th, having been held over from the preceding evening to take the fast freight. This through freight leaving North Bay daily at 2 p.m. is due at Fort William at 4.30 a.m. on the second day following; the train to which the first car was attached was due at Fort William on Monday morning at 4.30. Having seen the first car out at North Bay on Saturday afternoon, and made all arrangements with the trainmaster and the yardmaster for proper attention to the second car upon its arrival, the writer proceeded on Saturday evening to Fort William, and reached there on the following evening. The next morning (Monday), the first car being due, inquiries elicited the fact that it had not arrived. Upon request, the chief despatcher traced the car, found that it had been laid over at White River for repairs, as the report said, and that it would arrive at Fort William that evening by the way freight. As to despatch from Fort William to Winnipeg, the fast freight leaves Fort William daily at 5.30 a.m., and arrives at Winnipeg the next morning at 7.40. There is, however, a way freight that leaves Fort William in the evening, reaching Winnipeg some time the following night, and the yardmaster was requested to see that this car left by that train. The request was not attended to, and instead, the car was sent out by the through freight next morning, and reached Winnipeg Wednesday morning about 9 o'clock. From the freight yards the car was next to be placed at the siding of the Ottawa Fruit and Produce Exchange on Princess Street. There is a Winnipeg by-law that forbids the shunting of cars on sidings between the hours of 7 a.m. and 12 p.m. Hence, by the failure to send the car out from Fort William by the evening train as requested, a delay occurred of 24 hours in the placing of the car.

Now, mark the case in brief. The schedule rate of despatch by fast freight from North Bay to Winnipeg is 16 miles an hour. Provided the Grand Trunk would give the same service, the time from St. Catharines to North Bay would be 19 hours instead of 49. Provided, further, that connection is made at North Bay with the west-bound through freight, and the time from St. Catharines, Grimsby, and other fruit sections arranged accordingly, we should have, with the existing C. P. R. service, the following schedule, taking specific days and places for clearness:

St. Catharines to North Bay, 1 p.m. Friday to 10 a.m. Saturday; North Bay to Fort William, 2 p.m. Saturday to 4.30 a.m. Monday; Fort William to Winnipeg, 5.30 a.m. Monday to 7.40 a.m. Tuesday. To be unloaded and delivered on trucks, or placed on siding Wednesday morning. This would give a service of four or five days, instead of seven to eight days, as with the two experimental cars, and often longer as with ordinary shipments. Such a schedule as the above is perfectly feasible, and would require over the Grand Trunk portion of the line the establishment of a reasonably prompt through freight, and over the Canadian Pacific only the use of existing schedules.

The history of the second car was similar. It left North Bay on the afternoon of September 18, and according to schedule should have reached Winnipeg on the morning of the 21st. It reached its destination sometime on the 22nd, and was finally placed for unloading on the 23rd, seven days after loading.

These facts are reported not in any spirit of complaint, but simply to place upon record the conditions that surround freight traffic to the Northwest. It is quite obvious that over such an immense stretch of road, and with so large a volume of business as these companies control, accidents and delays occur that are unavoidable. It is, however, within the limits of reasonable expectation that a five day service for tender fruits be arranged from Southern Ontario to Winnipeg.

A report of these facts was sent to the Assistant Freight Traffic Manager of the C. P. R. and it elicited the following reply:

Dear Sir,—I am in receipt of your favor of the 8th, and am glad to learn the shipment of fruit to Winnipeg under your supervision proved a success.

In answer to your remarks regarding refrigeration, I would say it is expected and required that shippers will fully ice the cars at the point of shipment. If they instruct that the cars are to be re-iced in transit we will undertake to do this at each inspection and icing station, a list of which I gave you, and where necessary the bunkers will be replenished with ice. You will understand, of course, that varying weather conditions have a marked effect upon the ice in the cars, and it is very desirable that even though the temperature may be cool at the time of shipment the shippers should see a full supply of ice is put in the cars, because a change might take place before the next icing station is reached, and unless the bunkers are full, the ice may have disappeared before we have had an opportunity of inspecting or re-icing.

With regard to the time in transit. So far as our line is concerned from North Bay to Winnipeg, there is no reason, barring accident, why we cannot keep our schedule in the handling of fruit cars. You will understand, however, in a haul of such a length interruption may occur from time to time from causes over which we have no control. Fruit and other perishable freight is invariably handled on our line under red cards, and is followed by telegraph through each divisional point by our Superintendent of Car Service to insure despatch. We could not undertake to guarantee the time in transit. We will undertake, however, so far as we can, to see that fruit is given the best possible despatch at the time of handling. Your suggestion that we might run a special service once a week or oftener has already been found to be impracticable. We endeavored to establish such a service on a previous occasion, but found we could not induce the shippers to guarantee a sufficient number of cars to enable us to carry it out. In fact the dealers seemed to be disinclined to ship at the same time, and I believe there is also objection to their goods reaching the market at the same time, causing an overstock and sometimes a falling in prices.

I may say I am forwarding your letter to our Freight Traffic Manager, and will ask him to communicate the contents to the Superintendent of Car Service and our Superintendent of Transportation. I am sure both these gentlemen will do everything in their power to assist in the shipment of fruit from Ontario points to the west.

Yours truly,

W. B. Bulling.

(3) Icing. This particular, though deserving separate mention, will be briefly dealt with. The second car, from Grimsby, arrived at North Bay, according to the report received, with bunkers only one-fourth full of ice, and three tons of ice were added at that point. The amount added to the first car at North Bay was about one ton and three-quarters. There being no icing station at Grimsby, when the second car left there special instructions were given for re-icing at Hamilton. This probably was not done, and the car having been iced at Hamilton before loading on Wednesday, was not re-iced until it reached North Bay on Sunday. Excepting this omission, the icing was well attended to all along the line. The first car on reaching North Bay was about two-thirds full, and was filled there. When it reached Fort William it was full of ice, having probably been iced at Schreiber. No data were obtained with respect to the total amount of ice consumed, nor would such data be of much value by reason of the infinite variety of weather conditions that surround different shipments.

Under this head the attention of the reader is directed to the remarks on icing in the letter quoted just above.

(4) Charges. News was received at St. Catharines, before the first car was sent out, respecting the reduction of freight rates from 84 cents to 66 cents per hundred for mixed fruit. It is likely that our cars were the first to benefit by the more favorable rates. The change made a difference of $36 on each carload, 9 cents on a bushel of apples, and nearly 4 cents on a box of peaches.

The new rates for icing not having been fixed when the transportation charges were sent in, a flat rate of $16 was charged, which brought the total charge up to 74 cents a hundred for a carload of 20,000 pounds.

Before plans for the experiment were completed, the authorities of the Dominion Express Company were interviewed with a view to shipping an express load on one of the Company's patent ventilated cars. A request was made for a quotation of rates on carload lots from St. Catharines to Winnipeg. The Dominion Express Company not having rail connection at St. Catharines, the quotation was to include the Canadian Express charge from St. Catharines to the point where the Dominion Express would take charge of the car. After consideration, the company offered to carry the car, upon payment of the local rate of the Canadian Express Company, 30 cents a hundred, and a further charge of $2·25 a hundred for the portion of the line over which the Dominion Express ran, making a total of $2.55 a hundred. To this an alternative was offered by the company, namely to ship the fruit by electric line to Port Dalhousie, tranship to boat for carriage to Toronto and tranship again to the company's car at Toronto. This involved handling four times instead of twice, and loading twice by the company's agents. Success in shipping to the West requires as little handling as possible and careful loading, hence the alternative as well as the original offer, was dismissed as impracticable.

A comparison of express rates per ordinary car, namely $2.10 a hundred, with freight rates, 74 cents, gives the following figures, for tender fruits:

| | Express. | Freight. |
|---|---|---|
| Peaches, per box of 20 pounds | 42. cents. | 14.8 cents. |
| Pears, per box of 25 pounds | 52.5 cents. | 18.5 cents. |
| Plums, per box of 25 pounds | 52.5 cents. | 18.5 cents. |
| Grapes, per basket (6—100 pounds) | 35 cents. | 12.3 cents. |

An express car loaded at Grimsby could be placed and sold at Winnipeg three days after. But tender fruits well-selected, well-packed, and well-loaded would be safer in a refrigerator car for six days or eight days than in a hot, unventilated express car for three days. Our experiment has proved that tender fruits can be carried by freight with safety; and as to rates, the total freight charges are a little more than one-third of the express rates.

## IV. OBSERVATIONS ON THE MARKET IN WINNIPEG.

(1) The Prices Obtained, and Condition of Fruit. The following tables present in concise form information respecting the grade, quality and condition of the fruit, and the prices obtained. The column under "Net Proceeds" gives the returns to the grower after deducting charges for freight, commission, and cost of package, but not for packing and wrapping.

*Peaches:* The package used contains, in peaches wrapped in manila paper and tightly packed, slightly more than the 11-quart basket of bare peaches, about 13 quarts. Crawford peaches, XXX, realized from 85 to 90 cents net; Crawford XX, 70 to 80; Elbertas, 62½ to 80.

These prices compare very favorably with those obtained locally in Ontario this year, and Ontario prices this year are unusually high, while at Winnipeg prices are no higher than usual.

The peaches sold entirely on their appearance and quality, with no reputation to help them. It is very gratifying to note that the prices were fully equal to those for the best California peaches on the same dates. The greater size of the California fruit was quite counterbalanced by the superior brightness and color of our fruit.

With respect to competition of Ontario peaches with the Western product, it should be borne in mind that the latter suffers a serious handicap in the matter of charges. Against a freight charge of 15 cents on a box of peaches from Southern Ontario to Winnipeg, there is a freight charge of 36 cents from California, and in addition a duty of 19 cents, making a total of 55 cents—a handicap of 40 cents a box. In a letter addressed to a Winnipeg commission firm, the writer saw quoted 50 cents a box F.O.B. California. To compete with these California prices, peaches might be quoted 90 cents a box F.O.B. St. Catharines or Grimsby. In fact, with one exception, prime Crawford peaches sold in advance of this price, and the average net price obtained for No. 1 Crawfords, counting the price of the box, was 92 cents.

Package,—4¾ in. x 12 in. x 18½ in ; cost, 8c.

ST. CATHARINES.

| Shipper. | Variety. | Quantity. | Grade. | Quality. | Maturity. | Packing. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|---|---|---|
| C. E. Secord. ....... | Crawford .... | 4 | XXX | good..... | semi-firm | tight.... | ripe. .... | 1.25 | 35½ | 89½ |
| W. H. Bunting.... | Crawford ... | 5 | XXX | good..... | semi-firm | tight..... | ripe. .... | 1.20 | 35 | 85 |
| A. C. Gregory...... | Crawford .... | 21 | XXX | fair. ..... | firm...... | tight..... | firm..... | 1.20 | 35 | 85 |
| W. H. Secord...... | Crawford .... | 5 | XX | fair. ..... | semi-firm | .... .... | ripe. .... | 1.15 | 34½ | 80½ |
| Robt. Thompson... | Crawford .... | 10 | XX | fair...... | hard..... | .......... | firm...... | 1.13 | 34 | 79 |
| J. Burdy........... | Crawford .... | 10 | XX | medium.. | firm...... | .......... | firm...... | 1.05 | 33½ | 71½ |
| C. E. Secord....... | Elberta ...... | 1 | XXX | fair. ..... | firm...... | .......... | firm...... | 1.15 | 34½ | 80½ |
| J. H. Brodrick..... | Elberta ...... | 10 | XX | fair.. .... | hard..... | tight .... | hard..... | 1.05 | 33½ | 71½ |
| F. A. Goring....... | Elberta ...... | 10 | XXX | fair. ..... | hard..... | tight .... | hard..... | .95 | 32½ | 62½ |

GRIMSBY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| W. J. Drope. ....... | Crawford .... | 3 | XXX | good..... | firm...... | tight .... | firm...... | 1.25 | 35½ | 89½ |
| S. Cockburn ....... | Crawford .... | 9 | XXX | good..... | semi-firm | tight .... | ripe. .... | 1.22 | 35 | 87 |
| J. F. Brennan. .... | Crawford .... | 3 | XXX | good..... | semi-firm | tight ... | ripe. ... .. | 1.20 | 35 | 85 |
| .................. | Crawford .... | 47 | XXX | good..... | firm...... | tight .... | firm...... | 1.20 | 35 | 85 |
| E. M. Smith. ....... | Crawford .... | 12 | XXX | good..... | firm...... | tight .... | firm...... | 1.08 | 34 | 74 |

The low price on the last lot—74c. net— was due, not to any inferiority in the fruit, but simply to the uncertainty in the method of sale.

Fig. 7 shows two boxes of Ontario peaches with a box of California peaches between. It may be seen that the California fruit is larger; but in other particulars the Ontario fruit is superior. The photograph does not do justice to the fine colors of the Ontario fruit. A close inspection, however, will reveal these colors. The California box of fruit is uniformly pale, while the Ontario specimens show dark and pale alternately. The dark is, of course, the colored side of the peach, and the fine appearance of the original, as contrasted with the paleness of the California product, is at once evident.

*Plums:* The dealers at Winnipeg seemed somewhat timid in purchasing the plums, and did not offer high prices, although the fruit was in good condition. In terms of the 11-quart basket, the Reine Claude plums netted 47 cents, the Yellow Egg 54 cents, and the Grand Duke and Glass 48 cents. These prices are of course much below Ontario prices this year, and would not be considered high at any time.

Package,—12-tray crate, 10 in. x 11 in. x 21 in. ; 27 pounds of fruit.

ST. CATHARINES.

| Shipper. | Variety. | Quantity. | Grade. | Quality. | Maturity. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|---|---|
| W. H. Secord................ | R. Claude.... | 5 | XXX | good..... | firm...... | sound semi-firm | 1.50 | 75 | 75 |

Package,—2-basket crate ; 20 pounds of fruit.

GRIMSBY.

| Shipper. | Variety. | Quantity. | Grade. | Quality. | Maturity. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|---|---|
| E. M. Smith...... | Y. Egg....... | 48 | XXX | good..... | firm...... | soft. ... | 1.08 | 43 | 65 |
| .................... | G. Duke.. .. | 25 | XXX | good..... | firm...... | semi-firm | 1.00 | 42 | 58 |
| .................... | Glass ........ | 17 | XXX | good..... | firm...... | semi-firm | 1.00 | 42 | 58 |

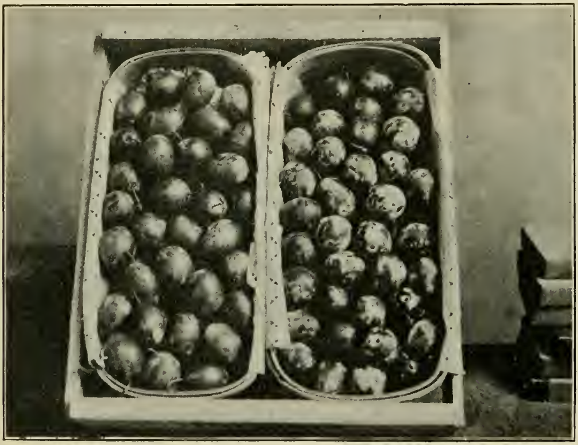


Fig. 8 shows the 2-basket-crate, and the condition of the plums at Winnipeg. The basket at the left contains Yellow Egg, the other Grand Duke. The spotted appearance of the latter is due to the partial bloom remaining on the fruit. These plums are shown just as they were opened up, and, as may be seen, are quite sound.

*Grapes:* With the exception of one lot of Moore's Early, of which a large percentage were off the stem, and which netted 66 cents, and one crate of Concord, which netted 70 cents, the grapes realized prices ranging from 75 cents to $1.02 per crate of 30 pounds. After deducting all charges and cost of packing, 40 to 50 cents a basket would be very nearly the equivalent of these prices. Had it not been for the excessive cost of the crate used—30 cents—the results would have been even more satisfactory.

Package,—Crate, 10 in. x 11 in. x 21 in., 12 trays ; cost, 30c.

ST. CATHARINES.

| Shipper. | Variety. | Quantity. | Grade. | Quality. | Maturity. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|---|---|
| J. R. Secord | Niagara | 2 | XXX | good | ripe | sound | 1.80 | 78 | 1.02 |
| J. H. Brodrick | Wy. Red | 3 | XXX | good | firm | sound | 1.75 | 77½ | 97½ |
| W. H. Nicholson | M. Early | 6 | XXX | good | ripe | | 1.65 | 76½ | 88½ |
| F. G. Stewart | M. Early | 20 | XXX | good | ripe | | 1.65 | 76½ | 88½ |
| J. H. Brodrick | Worden | 4 | XXX | good | | sound | 1.60 | 76 | 84 |
| J. R. Secord | Worden | 2 | XXX | good | ripe | sound | 1.60 | 76 | 84 |
| W. H. Secord | M. Early | 2 | XXX | good | | sound | 1.60 | 76 | 84 |
| C. E. Secord | M. Early | 10 | XXX | good | | off stem | 1.52 | 75 | 77 |
| J. H. Brodrick | M. Early | 8 | XXX | good | | sound | 1.50 | 75 | 75 |
| W. H. Secord | Concord | 1 | XXX | good | firm | sound | 1.45 | 74½ | 70½ |
| F. A. Goring | M. Early | 10 | XXX | good | ripe | off stem | 1.40 | 74 | 66 |

*Pears*: Packages,—5 in x 10 in. x 22½ in.; 5 in. x 11 in. x 20 in.; 5 in. x 12 in. x 18½ in ; cost, 8-10c.

GRIMSBY.

| Shipper. | Variety. | Quantity. | Grade. | Quality. | Maturity. | Packing. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|---|---|---|
| L. Woolverton | Bartlett | 21 | exXXX | good | semi-firm | slack | ripe | 1.05 | 39½ | 65½ |
| | Bartlett | 76 | XXX | good | semi-firm | slack | ripe | .70 | 36 | 34 |
| | Bartlett | 111 | XX | good | firm | slack | firm | .60 | 35 | 25 |
| | Bartlett | 94 | X | fair | firm | slack | firm | .55 | 34½ | 20½ |
| S. Cockburn | Bartlett | 15 | XXX | good | firm | | firm | .70 | 34 | 36 |
| S. F. Brennan | Bartlett | 10 | XXX | good | firm | squeezed | firm | .68 | 34 | 34 |
| A. H. Pettit | Bartlett | 7 | XXX | good | firm | tight | firm | .60 | 33 | 27 |
| W. Walker | Bartlett | 10 | XX | good | firm | | firm | .55 | 32½ | 22½ |
| J. F. Brennan | F. Beauty | 21 | XXX | fair | firm | squeezed | firm | .60 | 33 | 27 |
| | F. Beauty | 14 | XX | fair | firm | squeezed | firm | .60 | 33 | 27 |
| M. Pettit | F. Beauty | 100 | XXX | fair | hard | tight | hard | .58 | 35 | 23 |

Package,—5 in. x 10 in. x 22½ in.; cost, 10c.

ST. CATHARINES.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| H. S. Cole | Bartlett | 7 | XX | good | firm | tight | firm | 1.25 | 41½ | 83½ |
| F. Blaikie | Bartlett | 24 | XXX | good | semi-firm | | ripe | 1.13 | 40 | 73 |
| J. H. Brodrick | Bartlett | 11 | XX | fair | firm | slack | firm | 1.10 | 40 | 70 |
| J. Burdy | Bartlett | 5 | XXX | medium | firm | | firm | 1.10 | 40 | 70 |
| Titterington & Co. | Bartlett | 5 | XXX | good | firm | tight | firm | 1.10 | 40 | 70 |
| R. F. Robinson | Bartlett | 20 | XXX | good | semi-firm | tight | ripe | 1.01 | 39 | 62 |
| Robt. Thompson | Bartlett | 14 | XXX | good | semi-firm | tight | ripe | 1.00 | 39 | 61 |
| A. C. Gregory | Bartlett | 20 | XX | fair | semi-firm | slack | ripe | .99 | 39 | 60 |
| J. H. Brodrick | Seckel | 4 | XX | fair | hard | tight | hard | 1.00 | 39 | 61 |
| | Clairgeau | 8 | XX | fair | hard | slack. | hard | .95 | 38½ | 56½ |

For the sake of comparison, four lots of pears from one orchard, graded Extra XXX, XXX, XX, and X, are placed together. The Flemish Beauty lots, while good stock, were altogether too immature, and, as the prices show, were not wanted.

The pears shipped by H. S. Cole were marked XX on account of being ungraded and having a few small ones in each box. They were all of good quality and for the most part large enough for XXX.

Fig. 9 shows XXX Bartlett pears at Winnipeg. For the photograph, the wrapping was removed and the pears rearranged.

*Apples*: Package,—10 in. x 10¾ in. x 21 in.; cost, 14c.

St. Catharines.

| Shipper. | Variety. | Quantity. | Grade. | Quality. | Maturity. | Packing. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|---|---|---|
| W. H. Bunting | St. Lawrence | 13 | XXX | good | ripe | tight | | 1.16 | 63 | 53 |
| Titterington & Co. | Gravenstein | 21 | XXX | good | ripe | tight | | 1.08 | 62 | 46 |
| J. R. Secord | B. Pippin | 5 | XXX | fair | firm | | | 1.05 | 61½ | 43½ |
| W. H. Bunting | Cayuga | 29 | XXX | fair | firm | tight | | 1.03 | 61 | 42 |
| H. S. Cole | Cayuga | 10 | XX | good | firm | slack | | 1.03 | 61 | 42 |
| C. E. Secord | Gravenstein | 24 | XXX | good | firm | tight | | 1.00 | 61 | 39 |
| | H. Pippin | 13 | XXX | good | | | | 1.00 | 61 | 39 |
| | F. Pippin | 25 | XXX | good | | | | 1.00 | 61 | 39 |
| Robt. Thompson | Gravenstein | 28 | XXX | fair | firm | slack | | .98 | 61 | 37 |
| W. H. Bunting | St. Lawrence | 11 | XX | fair | firm | tight | | .94 | 60 | 34 |
| A. C. Gregory | Colvert | 13 | XXX | fair | firm | slack | | .93 | 60 | 33 |
| J. H. Brodrick | Wealthy | 1 | XXX | good | ripe | slack | | .90 | 60 | 30 |
| | Ind. Rareripe | 16 | XX | fair | firm | slack | | .85 | 59½ | 25½ |
| W. H. Nicholson | Gravenstein | 16 | XX | fair | firm | tight | | .85 | 59½ | 25½ |
| C. E. Secord | Gravenstein | 4 | XX | fair | firm | tight | | .84 | 59 | 25 |
| A. C. Gregory | R. Pippin | 6 | XX | good | firm | slack | | .82 | 59 | 23 |
| J. H. Brodrick | Kes. Codling | 6 | XXX | fair | firm | slack | | .75 | 58½ | 16½ |
| | Crab | ½ bu | XXX | good | | tight | | 1.05 | 61½ | 43½ |

The Cayugas shipped by H. S. Cole were ungraded and, therefore, marked by the inspectors XX, although mostly XXX stock.

Package,—10 in. x 10¾ in. x 21 in.; cost, 14c.

GRIMSBY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| L. Woolverton | Wealthy | 3 | XXX | good | | 1.13 | 62 | 51 |
| A. H. Pettit | Gravenstein | 5 | XXX | good firm | | 1.10 | 62 | 48 |
| | Alexander | 5 | XXX | fair | | 1.10 | 62 | 48 |
| | Gravenstein | 7 | XX | Medium green | slack | 1.00 | 61 | 39 |
| L. Woolverton | Gravenstein | 46 | XX | fair green | slack | .96 | 60½ | 35½ |
| W. J. Drope | B. Pippin | 6 | XXX | good firm | tight | .90 | 60 | 30 |
| A. H. Pettit | B. Pippin | 12 | XXX | fair | tight | .90 | 60 | 30 |
| | B. Pippin | 4 | XX | fair | | .90 | 60 | 30 |
| | Colvert | 20 | XXX | fair | slack | .85 | 59½ | 25½ |

*Tomatoes*: Package,—4¾ in. x 12 in. x 18½ in.; cost, 8c.

ST. CATHARINES.

| Shipper. | Quantity. | Grade. | Maturity. | Condition at market. | Price. | Charges. | Net proceeds. |
|---|---|---|---|---|---|---|---|
| J. H. Brodrick | 17 | XXX | rather green | sound, firm | .61 | 29 | 32 |
| W. H. Bunting | 15 | XX | do | sound, firm | .85 | 35 | 50 |

GRIMSBY.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| W. J. Andrews | 30 | XXX | rather green | sound, firm | .57 | 29 | 28 |

The difference in the tomato prices was due again, not to a difference in value, but to the fickleness of the auction method.

Comparing Winnipeg prices with those obtained in local and other markets this year, Mr. W. H. Secord, of Homer, Ont., writes: "I received as high as $1.25 per 11-quart basket for Reine Claude plums in Montreal, and it took eight baskets to fill five boxes. As to peaches, I shipped the same peaches to Toronto the next day after I delivered to you and received 80 cents per basket, which would net 63½ cents deducting freight, commission, and basket. On the whole, in my opinion, the prices realized do not equal those which we are receiving in the East this year. I am not prepared to say how it would be in a year like last, of plenty."

Mr. J. W. Brennan, of Grimsby, writes: "Our returns on peaches shipped the following day to Ottawa and Quebec netted us clear $1.25 and $1.29 per case.

"Just received returns from Glasgow, where a car of pears arrived in bad order, much too ripe. In that consignment our little lot brought us 70 cents clear; on others we believe less than one-half were realized."

(2) METHOD OF SALE. The fruit was sold by auction, and the method exhibited its usual advantages and disadvantages. It is inclined to unsteadiness. A glance over the tables of returns given above will reveal differences in prices that are not due to differences in values. On the other hand, this method enables rapid disposal of the goods, which is of importance for perishable fruits, and quick returns, which is satisfactory to

the shipper. With such limited experience, however, the writer does not feel competent to advise upon the method of selling, whether this or any other.

(3) Character of Fruit Demanded. If one may judge from the sale of two cars of mixed fruit, the market there demands well-matured, bright fruit of clean, sound appearance. Well-colored Crawford peaches sold much in advance of Elbertas, which, though large, were mostly hard and green. Immature fruit is not wanted. Many of the pears in the second day's sale were green and very firm, and sold low accordingly. Of apples, well-colored Gravensteins, Wealthy, Alexander, and St. Lawrence, commanded the best prices.

(4) Best Degree of Maturity. A careful examination of the fruit at Winnipeg revealed the fact that the most mature fruit at shipping point was in best condition at the market. Evidently all classes of fruit may be left on the tree until full size and characteristic color have been attained, but should be picked firm, and before the yellow tints, significant of ripeness, have begun to appear. Peaches and pears that were shipped hard and green reached the market without any perceptible change; those that were semi-firm at shipment had become sufficiently mellow to be in good usable condition. A special report was obtained of one box of peaches, among the primest of our two lots. This box at shipping point was reported "semi-firm, a little too ripe for shipment," and the peaches were large and well-colored. It was packed on September 15th, loaded September 16th, and sold at Winnipeg September 23rd. On Monday, September 26th, a report was obtained to the effect that only a few of the peaches were then mellow enough to use, and that by the end of the week the whole of the box would probably be sufficiently ripe.

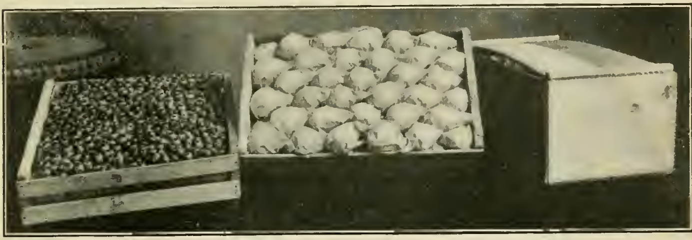
It seems an opportune moment to emphasize the importance of choosing carefully the time for picking and, for fancy fruits at least, of going over the tree several times and picking only the ripest at each picking. This phase of the question stands out clearly as a result of our experiment. The fruit should be allowed to attain on the tree its distinctive character, in size, color, and flavor. If, in these three particulars, the fruit is immature when picked, it will remain immature. And further, if fruit sufficiently mature to have its distinctive size, color, and flavor when picked, cannot be safely carried to market, then it is detrimental to the reputation of the fruit to carry any. The shipping of immature fruit, it is admitted, has done as much as anything to depreciate prices in distant markets.

What does the grower gain by the careful selection of fruit on the tree and by successive pickings? He gains (1) a greater quantity of fruit, since the smaller specimens are allowed to grow; (2) fruit of better appearance, on account of greater size, more uniform size, and higher color; (3) fruit of better quality; (4) in a discriminating market, better prices; (5) a better reputation.

(5) Packing as it Appeared at the Market. By packing is meant not merely the placing of the fruit in the package, but also the use of wrappers and fillers.

Two effects should be borne in mind in the packing of fruit: First, the condition of the fruit; second, the appearance of the package.

Packing should first of all be tight; and herein much of the work done for the two trial shipments was defective. Many of the boxes, upon being lifted to load in the car, rattled, which indicated a looseness of the fruit in the package. It is scarcely necessary to remark that such looseness is an unfavorable factor in the carrying of the fruit, and that it is useless to secure the package in its place in the car when the fruit within the package is capable of being displaced. Further, the looseness of the fruit, when the package is opened for exhibition and sale, impresses the dealer unfavorably, and tends to depreciate the price. Tightness of packing is just as necessary when the fruit is wrapped, as when it is not; for with loose packing and heavy wrappers, such as occurred too frequently in this shipment, the purchaser receives much less fruit than, if he judges by the size of the package, he expects and is entitled to receive. To illustrate: the weight of a box of pears put up by one shipper was 31 pounds; the



1 2 3

Fig. 10.—(1) The California grape-crate, a shallow square container holding 4 square trays.

(2) A box of pears packed by J. F. Brennan, of Grimsby. The pears are heaped toward the middle by selecting slightly larger pears for the middle; this heaping gives the effect, when the lid is on, as seen in (3) of this figure.

(3) Is a box of California pears 9 in. x 12 in. x 18½ in. By this style of packing the pears are squeezed when the lid is on, an effect similar to squeezing apples when heading the barrel.

weight of a box of same size, containing the same variety and grade of pears, put up by another shipper in the same car, was 23 pounds. The pears in both boxes were wrapped, but in the one the pears were squeezed, and in the other they were slack.

Some of the apples in our shipment were packed in layers, with a stiff heavy paper, cut the size of the box, between layers. This paper, while good in itself, was made by some of the packers the occasion for very loose packing. In fact, in some of the boxes there was no attempt at close packing; the apples being put in loosely on top of the paper, and faced stem upwards so as to present a level surface for the next paper. Such methods result to the packer in a considerable saving of apples, but rob the consumer, besides allowing bruising in transit.

Fillers. There is a practice in packing that cannot be too strongly condemned, namely, filling in the slack with odd pieces of paper, excelsior, and small and inferior specimens of fruit. The effect of this upon the intending purchaser, when the box is opened, has to be seen but once to impress anyone with the unwisdom, the shortsightedness of this style of work. The ragged, untidy, make-shift appearance, the evident lack of skill, the danger that dishonest intention be imputed, are some of the unfortunate consequences. The filling known as "Excelsior" is in this regard made to cover a multitude of sins, and for this reason, if for no other, its use should be discouraged. Especially is excelsior superfluous when the fruit is wrapped, as then it is not required to serve its only useful purpose, namely, to prevent the fruit from bruising. Yet by several of our packers excelsior was used to fill up the slack between the top layer of peaches and pears and the lid; whereas, with a proper selection of size of specimens and ordinary care and skill in packing, there should have been no slack. With excelsior at the bottom of the box, and excelsior at the top, and excelsior sticking out at the crevices and forming a ragged edge all around, the appearance of some of our peach boxes compared very unfavorably with the neat and tidy Californian boxes in the same warehouse, and, it is only just to say, with other boxes sent out by our own packers.

Wrapping Paper. The writer is inclined to advise, but without having personally made an exact and thorough test, that tissue paper is not heavy or strong enough to protect Ontario peaches in shipment. Tissue paper may do well enough for pears, or for California peaches, which are drier and firmer than our own; but for the soft and juicy peach of Ontario a manila paper seems to give better results. This, however, should not be so thick and heavy as to bulk up unnecessarily, and particularly, should be of a size proportioned to the size of the fruit to be wrapped. Here again, the long-suffering consumer, who thought he was paying for prime Ontario peaches, found upon opening some of the boxes that he had purchased large twists of paper, with a comparatively insignificant peach done up in a pocket at the end of each. In many cases, the paper used was altogether too large. Now, what does this fact signify? Evidently, that the packers were not in the habit of wrapping their peaches for market, were not provided with paper of the proper size and weight, and when the time came for them to fulfill this contract, were forced to use whatever was at hand, or could be procured at short notice. One packer, driven to desperate expedients, but as he confessed, well aware of the ludicrous nature of the performance, used toilet paper for wrapping his pears. It is quite evident that the business of packing the fruit has not yet received serious attention from many of our fruit-growers. The time is coming, and cannot come too soon, when peaches will be wrapped and boxed for shipment to our local markets.

## V. SOME NOTES ON DIMENSIONS OF PACKAGES IN RELATION TO COOLING.

The question of size and shape of package to be used with any particular variety is of first-class importance in storing or shipping fruit; important not merely in respect of cost and convenience of package, or the degree of firmness of the fruit that will sustain the weight of the fruit above it in the package; but important more especially on account of the rate at which the whole of the fruit in the package will cool to the temperature of the refrigerator. Slowly ripening fruits, such as winter apples and winter pears, may be safely packed in a case that cools slowly. But quickly ripening fruits, to be preserved, must be cooled very quickly to a temperature of 40 degrees or below, in order to delay the ripening and decaying processes. With a peach that will ripen and begin to decay two days after picking, a few hours' delay in cooling will make relatively a great difference in the length of its life. For such fruit as this, a package must be used that allows the most rapid rate of cooling.

With these principles in mind, the following temperature tests were made at the Cold Storage Warehouse at the Agricultural College. Four packages were filled with apples, and long thermometers were inserted in the midst of the fruit, the bulbs being at the centres of the packages and the stems and reading scales standing out of the packages in view of the observer. The packages were then headed, placed in a warm room and kept for a week until they reached a uniform temperature of 64 degrees F., and then were transferred to a room in the warehouse that is kept at a temperature of from 32 degrees to 34 degrees. The packages were:

1. An ordinary large apple barrel.
2. A bushel box 10x11x20 inches, with close joints practically air tight.
3. A Georgia peach carrier 10x11x20 inches, with open spaces at sides; the fruit within was packed in the six baskets, and among these baskets were empty spaces permitting circulation of air.
4. A half-bushel box 5x11x20 inches, with open spaces at sides, bottom and top.

| Package | Time of observation | | Amonnt of cooling | | | |
|---|---|---|---|---|---|---|
| (1) | a.m. p.m. | | | | | |
| Barrel | 10.30 to 2.00 | 3½ hours | 64.5 | 60.5 | equal | 4° |
| Bushel (closed joints) | 10.30 to 2.00 | 3½ hours | 64.5 | 57.5 | " | 7° |
| Bushel (open) | 10.30 to 2.00 | 3½ hours | 64.5 | 54 | " | 10½° |
| Half-bushel | 10.30 to 2.00 | 3½ hours | 64 | 51 | " | 12° |
| (2) | p.m. p.m. | | | | | |
| Barrel | 2.00 to 8.00 | 6 hours | 90.5 | 57 | " | 3½° |
| Bushel (closed joints) | 2.00 to 8.00 | 6 hours | 57.5 | 50 | " | 7½° |
| Bushel (open joints) | 2.00 to 8.00 | 6 hours | 54 | 43 | " | 11° |
| Half-bushel | 2.00 to 8.00 | 6 hours | 51 | 40 | " | 11° |
| Total: | a.m. p.m. | | | | | |
| Barrel | 10.30 to 8.00 | 9½ hours | 94.5 | 57 | " | 7½° |
| Bushel (closed joints) | 10.30 to 8.00 | 9½ hours | 64.5 | 50 | " | 14½° |
| Bushel (open joints) | 10.30 to 8.00 | 9½ hours | 64.5 | 43 | " | 21½° |
| Half-bushel | 10.30 to 8.00 | 9½ hours | 64 | 40 | " | 24° |

The half-bushel, it may be seen, had cooled to a sufficiently low temperature, 40 degrees, in 9½ hours; the Georgia crate, with open sides and open packing, cooled in the same time within 30 degrees of that temperature. By the next morning at eight o'clock the half-bushel had cooled to 35 degrees, the Georgia crate to 35 degrees, the bushel to 39 degrees, and the barrel to 47 degrees. Two days after the commencement of the observations the barrel was still at a temperature of 38 degrees, 6 degrees above that of the room.

The application of these facts is obvious: Winter apples and winter pears may, so far as temperature and ripening are concerned, be packed in barrels. For winter pears, no package smaller than the bushel box need be used. Between the half-bushel and the bushel, there was in the above test a difference of 12 hours in cooling from a temperature of 64 degrees to 40 degrees; but this difference is insignificant with slowly ripening fruit.

For summer and early fall apples the barrel is too large a package, and much of this fruit shipped in barrels turns out badly by reason of the slowness of cooling. Where decay occurs it is usually at the centre of the package, because this is the last to cool. The bushel box, cooling to the centre in half the time that the barrel requires, is for this reason preferable to the barrel for early apples.

For early and quickly ripening pears, the bushel box is too large a package for best results in long shipments, unless it be in the form of the Georgia carrier with open sides, when it resolves itself virtually into a number of small packages with spaces between. The writer chanced to call upon a retail dealer at Winnipeg and found him unpacking some Ontario pears, Bartletts, from bushel boxes. There was a marked difference between the pears next to the package and those at the centre. Those at the outside were still green and firm, while those at the centre were quite ripe, and many of them soft and pulpy. The use of the half-bushel box in this instance instead of the bushel, would have hastened the cooling of the centre of the package by 12 hours, and would likely have preserved the fruit at the centre.

All results of storage and shipping experiments concur in pointing out the necessity for quick cooling of tender fruits. Such fruits should be packed in shallow cases and placed in a cold store as soon as possible after picking.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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| 107 | May 1898 | Dairy Bulletin (out of print, see No. 114) | Dairy School. |
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ONTARIO AGRICULTURAL COLLEGE.

# BULLETIN 140.

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# The Results of Field Experiments with Farm Crops.

By C. A. ZAVITZ, B.S.A.,
Professor of Field Husbandry and Director of the Experimental Department.

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BULLETIN 140 FEBRUARY, 1905

# Ontario Agricultural College and Experimental Farm

## THE RESULTS OF FIELD EXPERIMENTS WITH FARM CROPS—1904.

By C. A. Zavitz, Professor of Field Husbandry.

The work in the Experimental Department consists in planning the various experiments; laying out, seeding, and looking after the field plots; harvesting, threshing, weighing, and testing the grain; taking up, weighing, counting, testing and storing the potatoes and roots; cutting, weighing, and harvesting the grass, corn, and fodder crops, etc., and also in picking by hand the samples of grain grown on the plots, some to be sown on the plots the following year, and some to be distributed for co-operative experimental work throughout Ontario. But few people realize what a large amount of very careful thought is required in planning, supervising, and examining these plots, and in studying, comparing, and summarizing the results for presentation in reports, bulletins, newspaper articles, and lectures.

Experimental Grounds. About fifty acres of land, divided into about 2,000 plots, are used for agricultural field experiments, conducted with varieties of grain, root, tuber, grass, clover, fodder, silage, and miscellaneous crops; with artificial, green, and farmyard manures; with methods of cultivation, selection of seed, dates of seeding, etc.—all with the greatest care, and for several years in succession—in order to secure strictly accurate and reliable results. These experiments deal with the crops grown on over nine-tenths of the cultivated land in Ontario, that is, fully 10,000,000 acres.

Experimental Plots. The experimental grounds have a gentle slope towards the southwest, and the soil is what might be termed an average clay loam. Nearly one-quarter of the land is manured each year with twenty tons (about twelve loads) of farmyard manure per acre. It will thus be seen that the most of the land receives farmyard manure once every four years. No commercial fertilizers are used except in distinct fertilizer experiments, which occupy from two to three acres each year, and on which tests are made to ascertain the comparative value of different fertilizers with different crops. The plots vary in size according to the requirements of the different experiments, and the yields per acre are determined from the actual yields of the plots in every instance.

### Results of Experiments.

All our field experiments are conducted for at least five years before any of them are dropped. For the results of many of the tests which were carried on for five years previous to 1904, the reader is referred to former reports. The results of some of the experiments which have yet been conducted for only one or two years are held back until the tests can be carried through at least another summer. As different seasons vary so much in temperature, amount of rainfall, etc., the average results of experiments continued for several years are of much greater value than those secured from only one year's work. We submit the results with much confidence in their reliability and in their real, practical value. The writer has had good reason to believe that the work of the Experimental Department is being appreciated by the farmers of the Province, and that the results are being studied more and more each succeeding year. I shall limit my remarks on each separate experiment, the results of which are here presented, to a few of the points which seem to be of the greatest value to the agriculture of Ontario.

## Conditions of the Weather During the Past Summer.

In studying the results in the bulletin here presented, we should keep in view the conditions of the weather during the growing season. The past summer has been comparatively cool and wet. According to the report of the Bureau of Industries, the mean temperature for April was only 37.6 degrees as compared with 43.3 degrees in 1903, and 41.9 degrees above zero for the period extending from 1882 to 1903. The average temperature for each of the months of May, June, July, August, and September, for 1904, was lower than that for each of the corresponding months in the average of the past twenty-three years.

The total precipitation for the six months, starting with April, was 19.96 inches, according to the report of the Bureau of Industries for Ontario, and 19.87 inches according to the report of the Physical Department of the College at Guelph. This amount of rainfall is greater than for several years at the College, even including 1902, in which year the precipitation was also very large. According to the report of the Bureau of Industries, the average rainfall for Ontario from the year 1882 to 1903 was 15.7 inches for the six months commencing with April in each year. It will therefore be seen that the rainfall for 1904 was about 27 per cent. greater than for the average of the past twenty-three years. The rainfall at the College in July was exceedingly heavy, there being practically five inches during the month .

The first seeding which took place in the experimental plots in 1904 was on the 22nd of April. This was twenty days later than the first seeding in 1903. The grains were mostly sown during the last week in April and the early part of May. The mangels, sugar beets, carrots, and potatoes were mostly planted in May, and the corn, sorghum, turnips, rape, millet, beans, and part of the potatoes in June.

## FLUCTUATIONS IN THE AREAS OF FARM CROPS IN ONTARIO.

It is indeed interesting to study the crop production of Ontario from year to year. Owing to changed conditions brought about by means of fluctuations in the market prices of farm products, the introduction of new and improved varieties of farm crops, the amount of farm help available, the damages caused by insect pests and fungous diseases, as well as by other causes, we find considerable variations in the relative areas devoted to our principal farm crops over a series of years. A table has been compiled from the reports of the Ontario Bureau of Industries, and it is presented here to show the area devoted to each farm crop in Ontario in 1904, the average yield per acre of each crop for the past twenty-three years, and the percentage of increase or decrease in the area used for each of the crops for the past five years. The crops mentioned in the table are arranged in the order of their increase or their decrease per acre for the five years from 1899 to 1904.

| Farm Crops. | Acres of each Crop in Ontario in 1904. | Yield per Acre. Average 23 Years. | Percentage Increase or Decrease in Area in last 5 Years. |
|---|---|---|---|
| Barley | 772,434 | 1,301 lbs. | 57 Increase |
| Mangels | 71,344 | 459 bus. | 34 " |
| Beans | 50,892 | 1,026 lbs | 26 " |
| Pasture | 3,183,673 | | 18 " |
| Hay and clover | 2,926,207 | 1.45 tons | 17 " |
| Oats | 2,654,936 | 1,217 lbs. | 12 " |
| Corn for silage or fodder | 193,115 | ...................... | 12 " |
| Corn for husking | 329,882 | ...................... | 1 Decrease |
| Rye | 130,702 | 913 lbs. | 5 " |
| Turnips | 133,207 | 487 bus. | 13 " |
| Potatoes | 133,819 | 115 bus. | 20 " |
| Buckwheat | 100,608 | 936 lbs. | 23 " |
| Winter wheat | 608,458 | 1,218 lbs. | 42 " |
| Spring wheat | 225,027 | 942 lbs. | 44 " |
| Carrots | 6,634 | 348 bus. | 44 " |
| Peas | 339,260 | 1,170 lbs. | 54 " |

From the figures here presented, it will be seen that the areas devoted to the growth of barley, mangels, and beans are being increased rapidly at the present time. It will be noticed also that the hay and pasture land has been increased 17 and 18 per cent. within the past five years. These two crops alone now cover about six million acres of Ontario land each year. The increase in the amount of pasture and hay land in recent years has probably been due, to a very great extent, to the greater number of cattle which is being kept at present as compared with former years. A very noticeable feature in connection with this study is the fact that the area devoted to each of the crops—winter wheat, spring wheat, carrots, and peas—has decreased upwards of 40 per cent. in the last five years. We find that in 1897, 896,735 acres were used for the pea crop. From that time to the present, the acreage has gradually decreased until in 1904 there were only 339,260 acres of peas. This great decrease in Ontario's pea crop has been brought about largely through the ravages of the pea weevil. As the acreage has been reduced to such a large extent, the few who grow peas at the present time in the older parts of the Province should be very sure to fumigate the crop with carbon bisulphide immediately after harvest, in order to check the ravages of this troublesome pest. For the method of treatment, the reader is referred to another part of this report. We submit the foregoing table, believing that it contains much useful information in studying the present conditions regarding the growing of farm crops in Ontario.

## Yields Per Acre of Different Classes of Grain.

Besides making a careful study of the varieties of grain crops of any one class, it is well for us to compare the different classes of grain one with another. In the table presented under the previous heading, it will be noticed that the average number of pounds of grain per acre per annum for Ontario for the past twenty-three years has been as follows: Barley, 1301 lbs.; winter wheat, 1218 lbs.; oats, 1217 lbs.; peas, 1170 lbs.; beans, 1026 lbs.; spring wheat, 942 lbs.; buckwheat, 936 lbs.; and rye 913 lbs. Thus we see that of the principal farm crops which have been grown throughout Ontario for the last twenty-three years, barley has given the largest number of pounds of grain per acre. The increase in the yield of barley over oats is fully 14 per cent.

In comparison with the results for twenty-three years, it might be interesting to notice the results of some of the same crops over Ontario for the years 1902, 1903, and 1904. Taking the average of these three we find that the annual production in yields of grain per acre are as follows: Barley, 1584 lbs.; oats, 1390 lbs.; winter wheat, 1360 lbs.; peas, 1128 lbs.; spring wheat, 1082 lbs.; beans, 970 lbs.; and rye, 941 lbs. These results again show that the barley comes first, and the oats second in yield of pounds of grain per acre. It also shows that the yields of all the crops except beans have been considerably higher during the last three years than they were in the average of the past twenty-three years.

As some of these same kinds of crops were distributed throughout Ontario in the spring of 1902, 1903, and again in the spring of 1904, for co-operative experiments, a reference to the results obtained will be interesting for comparison with the results in general farm practice. It should be understood that the crops grown throughout Ontario are the averages of a large number of tests made on separate farms. The average soil on which any one crop would be grown would, therefore, not be exactly the same as the average soil used for the experiments with other crops. It should also be remembered that the results here presented are those of small plots, and not of large fields.

The results, however, were obtained from very carefully conducted experimental work.

| Class of Crops. | Variety. | Average Yield per Acre. Tons of Straw 3 Years. | Pounds of Grain. 1902. | 1903. | 1904. | Average 3 Years. |
|---|---|---|---|---|---|---|
| Emmer .. .. .. | Common .. .. . | 1.7 | 2,126 | 1,810 | 1,658 | 1,865 |
| Barley .. .. .. | Mandscheuri .. | 1.5 | 1,672 | 2,158 | 1,739 | 1,856 |
| Oats .. .. .... | Early Britain | 1.6 | 1,737 | 1,853 | 1,685 | 1,758 |
| Peas .. .. .. .. | Siberian .. .. | 1.5 | 1,166 | 1,955 | 1,692 | 1,604 |
| Hulless Barley | Black .. .. .. | 1.4 | 1,536 | 1,448 | 1,607 | 1,530 |
| Spring wheat .. | Wild Goose .. . | 1.4 | 1,302 | 1,078 | 1,169 | 1,183 |

We notice from the results of the co-operative work over Ontario that the barley has given a greater yield than the oats. We also notice that the Emmer occupies the highest place in yield of grain per acre, being slightly ahead of barley in grain production. This grain has not been grown in general cultivation throughout Ontario, but will be described more fully further on in this report. It will be observed that the yields in connection with the co-operative work throughout Ontario for the last three years have been somewhat greater than the yields given in the report of the Bureau of Industries.

An experiment was conducted at the College in 1902, in 1903, and again in 1904, in order to obtain some definite information regarding the comparative yields of the different classes of farm crops, grown and handled under as nearly uniform conditions as possible. The seeding took place on April 24th in 1902, on May 5th in 1903, and on May 4th in 1904, and the experiment was conducted in duplicate in each year. The figures here presented give the average results, therefore, of six separate expriments in growing farm crops under similar conditions within the past three years.

| Class of Crops. | Variety. | Average results for three years—Six tests. Date of ripening. | Height. | Rust. | Yield per acre. Straw. | Grain. |
|---|---|---|---|---|---|---|
| | | August | Inches. | Per cent. | Tons. | Pounds. |
| Barley .. .. .. | Mandscheuri .. | 5 | 40 | 9 | 2.0 | 2,714 |
| Emmer .. .. .. | Common .. .. | 21 | 39 | 5 | 2.1 | 2,634 |
| Oats .. .. .. | Joanette .. .. . | 16 | 40 | 7 | 3.0 | 2,634 |
| Hulless Barley | Black .. .. .. | 6 | 31 | 13 | 2.1 | 2,473 |
| Early Oats .. | Alaska .. .. .. | 9 | 42 | 11 | 2.2 | 2,399 |
| Hulless Barley | White .. .. .. | 9 | 34 | 5 | 1.8 | 1,942 |
| Spring Wheat .. | Wild Goose .. .... | 29 | 48 | 13 | 2.2 | 1,716 |
| Spring Rye .. | Common .. .. . | 16 | 51 | 4 | 2.1 | 1,536 |
| Vetches .. .. .. | Spring .. .. .. | Sept. 12 | 38 | .. | 2.0 | 7.19 |

We notice from the table here presented that the barley again comes ahead of the oats in number of pounds of grain per acre. The barley is followed by the Emmer and the Joanette oats, which have given exactly the same yield of grain per acre. It might be well to here mention that, on the average, barley has about 12 to 15 per cent., Emmer about 22 per cent., and oats about 30 per cent. of hull. The Joanette variety of oats, however, has a particularly thin hull, the average percentage of hull being only about 23 per cent. Of the crops under experiment, the Mandscheuri barley, Black Hulless barley, Alaska oats, and White Hulless barley were the earliest; and the Common Spring vetches, and the Wild Goose spring wheat were the latest in reaching maturity. There is not much difference in the strength of straw of the Mandscheuri barley and the Common Emmer. Both, however, are considerably stronger than that of the Black Hulless barley. It should be remembered that the results presented in the last two tables are obtained from plots, and that the results taken from the reports of the Bureau of Industries were obtained from large areas of land.

## Barley.

Barley is one of the hardiest of the cereals and can be raised through a great range of climate. It is cultivated with success north of the Arctic circle, and at high altitudes in the torrid zone. This crop has been under cultivation in the southern part of Europe from the earliest times.

Barley was formerly grown extensively in Ontario for shipment to the United States for malting purposes. The high tariff placed on barley by the United States Government, however, was instrumental in shutting out a large quantity of the Ontario barley from the markets of that country. The acreage, therefore, decreased from year to year, until the introduction of large yielding varieties for feeding purposes and the demands of the live stock industry called for a greater amount of valuable feed. By examining the reports of the Bureau of Industries, we find that the acreage of barley in Ontario has increased no less than seventy-six per cent. within the past seven years. In 1904, there were upwards of three-quarters of a million acres of Ontario lands devoted to the growing of this important crop.

Varieties of Six-rowed Barley. Ontario seems particularly adapted to the growing of six-rowed barley; hence a good deal of attention has been given by the Experimental Department to secure those varieties which would likely give better results throughout the Province than the kinds which had been grown in former years. In the five years from 1889 to 1893, eighty-six different varieties of barley were grown in the experimental grounds. After five years' tests were completed, the poorest varieties were dropped from the experiment, and those which proved the most successful were retained for future experiments. New varieties were added from time to time, all of which were tested for at least five years. A few varieties have now been grown for fifteen years in succession, without change of seed. The results of these varieties are exceedingly interesting and worthy of careful study. The following are the average yields of grain per acre of each variety for the whole period of fifteen years, and also for the last five years:

| Varieties. | Average yield of grain per acre. | |
|---|---|---|
| | 1890-1904, 15 years. | 1900-4, 5 years. |
| Mandscheuri | 71.4 | 73.5 |
| Common six-rowed | 62.4 | 68.7 |
| Oderbrucker | 64.4 | 68.0 |
| Mensury | 60.0 | 63.1 |

The results show that the Mandscheuri gave decidedly the greatest yield per acre of the four varieties for the whole period of fifteen years, and also for the last five years. The Mandscheuri gave an average of 9.3 bushels per acre per annum over the Common Six-rowed barley in the average results for fifteen years. The average area devoted to barley in Ontario from 1882 to 1904 is given as 633,290 acres per annum. An increase of nine bushels of barley per acre throughout the Province would, therefore, amount to an increase of over five million bushels of barley in Ontario annually. This increase at fifty cents per bushel would amount to about two and a half million dollars. Two and a half million dollars annually would pay the running expenses of about thirty Agricultural Colleges like the one located at Guelph. The Mandscheuri barley was imported from Russia by the Ontario Agricultural College in the spring of 1889. Not only has it made a very excellent record at the College, but it has given high results in the co-operative experiments throughout Ontario and has been grown in general cultivation very successfully during the past few years. In looking up the records of the Bureau of Industries, we find that the average yield of barley throughout the Province for the period of ten years from 1895 to 1904, inclusive, is 29.3 bushels per acre; while that for the period of ten years from 1885 to 1894 inclusive was 24.85 bushels per acre. This shows an annual average increase of about 4 1/2 bushels per acre for the latter as compared with the former period of ten years. From these results, does it not appear as though the introduction of the Mandscheuri barley by the Ontario Agricultural College has been worth to the Province of Ontario within the past ten years an annual money value equal to more than fifteen times the entire cost of the College?

Among the other varieties of six-rowed barley which have been grown in the Experimental Department besides those already referred to, mention might be made of the California Brewing, Scotch Improved, Imperial Six-rowed, Success, and Ohio Beardless. Of these varieties, however, the only one which has given a very high average yield per acre is the California Brewing. This, however, is a coarse barley with a very stiff beard and straw of rather poor quality.

Variety of Two-rowed Barley. The two-rowed barley is easily distinguished from the other species by the head being somewhat elongated, and by there being only two rows of grain from one end of the head to the other. The heads of some varieties are long and slender; while those of other varieties are short, very broad at the base, and taper towards the extremity. The two-rowed barley is largely cultivated in England and Central Europe, but is not grown to any extent in Ontario, although great efforts were made a few years ago by the Dominion Government to have it grown extensively by Canadian farmers for exporting to England. With this object in view, the Canadian Government imported 10,000 bushels of the Carter's Prize Prolific barley from England, and sold the same to Canadian farmers at $2 per bushel, in order to get it introduced. This variety, however, has not given very satisfactory results throughout the Province.

According to the results of eleven years' experiments with about sixty varieties of two-rowed barley, we find that the highest yielding kinds are not as productive as the most prolific varieties of the six-rowed class. In the average of eleven years' tests with six varieties of two-rowed barley, the greatest yields were produced by the Two-rowed Canadian, New Zealand Chevalier, Jarman's Selected Beardless, and French Chevalier.

In 1904, seventeen varieties of two-rowed barley were grown in the experimental grounds. The highest yields were produced by the Two-rowed Canadian and Selected Canadian Thorp varieties; and the lowest yields were produced by the Invincible, Standwell, and Frederickson varieties. The last three varieties were recently imported from Europe. The Standwell and the Invincible were imported from England, and the Frederickson from Germany. The Chevalier two-rowed barley has been used considerably for mixing with Siberian or Banner oats for seed purposes. As the Chevalier barley is late in maturing, it ripens about the same time as either of these varieties of oats, and a mixture composed of the Chevalier barley with one of these varieties of oats usually produces a heavy yield per acre.

Varieties of Hulless Barley. The grain of the Hulless barley usually weighs about sixty pounds per measured bushel, while the standard weight of the common varieties is forty-eight pounds per bushel. The skin of the Hulless varieties is thin and transparent, and is white, purple, or black in color. In some respects the grain resembles wheat more than barley. The straw is apt to be weak, and. when ripe, often becomes so brittle that the heads are easily broken off. Some of the varieties possess heads with six rows, and others with two rows.

We have had ten varieties of Hulless barley under experiment for five years in succession, and find that the Guy Mayle heads the list with an average of 54.4 bushels per acre, taking sixty pounds as the standard weight per measured bushel. This is followed by the Black Hulless with 51.5; the Hungarian, 50.2; the Purple, 49.2; the Winnipeg No. 2, 46.9; the Hog, 45.9; the Large Skinned, 42.8; the New White Hulless, 42.1; and the Ideal, 40.2 bushels per acre. In 1904, the highest yields were produced by the Guy Mayle, 59.7 bus.; Black Hulless, 54.9 bus.; Purple, 53.2 bus.; and Hungarian 53.1 bushels per acre.

The Guy Mayle variety, which stands at the head of the list in yield per acre for five years, and also for 1904, produces a grain of purple color, and possesses straw which is comparatively strong for a Hulless barley. This barley was distributed throughout Ontario in 1904 for co-operative experiments. In the average of thirty-three reports of successfully conducted experiments with the Guy Mayle and the Black Hulless varieties, it was found that not only did the Guy Mayle give the larger yield of grain per acre, but it was the most popular of the two varieties among the experimenters. This is considered to be the most promising variety of Hulless barley which has been grown at the College.

Previous Cropping of Land for Barley. In the spring of 1901, a strip of land two rods in width and forty rods in length was divided into thirty-two plots. Paths five links (39.6 inches) in width were allowed between the plots. The land is very level throughout, and had been uniformly cropped previous to the date here mentioned. In the spring of 1901, the whole range was sown to early oats. No. 1 plot was seeded with Common Red Clover, No. 2 plot with Alsike Clover, No. 3 plot with Timothy, and No. 4 plot received no clover or grass seed. Similar seedings to these were repeated until the whole range was seeded according to the plan outlined above. It will, therefore, be seen that there were eight plots of Common Red Clover, eight plots of Alsike Clover, eight plots of Timothy, and eight plots left without seeding. After the oats were cut, the plots were carefully edged. Both the clover and the timothy made good growth in the autumn. In the following spring, the growth of the three crops on the twenty-four plots was excellent. The range was divided into two sections, and each section into four divisions, each division containing one plot of Common Red Clover, one plot of Alsike Clover, one plot of Timothy, and one plot without any crop. The land in No. 1 division was plowed after the first crop of the season had received its full growth and before it had been removed from the land; No. 2 division was plowed immediately after the first crop of the season had been removed; No. 3 division was plowed before the second crop had been removed; and No. 4 division was plowed immediately after the second crop had been removed from the land. The remaining sixteen plots were an exact duplicate of the first section. The land was cultivated on the surface in the autumn and was sown with mangels in the spring of 1903. The Sutton's Mammoth Long Red variety was used in the first section, and the Yellow Leviathan variety in the second section. On the same land, we sowed barley in the spring of 1904, using the Mandscheuri variety on the first section, and the Oderbrucker on the second section.

Taking the average of all the experiments in 1903, we find that the Common Red Clover land produced 2.1 tons and the Alsike Clover land 3.6 tons of mangels per acre more than the Timothy land. In the average results of the experiments for 1904, we find that the Common Red Clover land produced 8 bushels, and the Alsike Clover land 7.2 bushels of barley per acre more than the Timothy land. The greatest average yield of roots per acre (35.5 tons) in 1903, and the greatest average yield of barley per acre (58.2 bushels) in 1904 were produced on land which had received the first crop of Alsike Clover as green manure. It is intended to sow these plots with another crop in 1905, in order to study the manurial effects of the different crops plowed under for a series of years. This whole experiment is being repeated at the present time, as thirty-two other plots were treated in 1904 in the same manner as the plots previously referred to were treated in 1901.

We have previously conducted a series of experiments at the College in order to ascertain the comparative value of clover and grass sod for crop production. We first grew clover and grasses upon separate plots and removed the crops, after which the land was plowed and other crops were sown. The results, therefore, show the influence of the roots remaining in the land upon the productiveness of the crops following the clovers and grasses. In 1902, barley was sown after each of four varieties of clover and three varieties of grasses in four different places in our experimental grounds. The average results of the four tests in pounds of barley per acre were as follows: Red Clover, 1516; Lucerne, 1450; Alsike Clover, 1427; Mammoth Red Clover, 1408; Meadow Fescue Grass, 1068; Orchard Grass, 1015; and Timothy, 946. It will, therefore, be seen that the Red Clover sod gave an increase over the Timothy sod of 570 pounds, or nearly 12 bushels of barley per acre.

The results of this experiment help us to appreciate the beneficial influence on the soil from the growing of clover.

Winter Barley. Within the last twelve or fourteen years, we have sown winter barley each autumn. When the winters have been unfavorable, however, the barley has usually been winter-killed, and in those seasons in which the barley survived the winter, the results have been exceedingly good. In eight out of the past twelve years, the barley has survived the winter well, the average yield for the eight years being 64.1 bushels per acre. The crop during the last winter was considerably winter killed, but the plants which were alive in the spring made an excellent growth, and the yield obtained this season amounted to 31.8 bushels per acre. This, however, is only about one-half as large a yield as that shown for the average results for eight years. By making use of the same variety of winter barley from year to year, we hope that it will improve in hardiness as time advances, and that possibly we may secure a variety which will withstand our winter seasons without much risk of loss through winter killing.

## Oats.

Oats have been cultivated for such a long time without any definite record in regard to their origin that their native country is still unknown. The wide range of soils on which oats can be grown successfully, and the comparatively low temperature in which they come to their maturity, have rendered them well adapted for cultivation in many countries. In some countries of the world, the cultivation of oats extends very far north, even to the 65th degree of latitude. In Ontario, the area devoted to oats each year is greater than that used for the cultivation of any other kind of grain. The number of acres used for oats in Ontario was 2,654,936 in 1904, and 2,058,487 acres in the average of the past twenty-three years. The average yield of oats per acre throughout the Province has been gradually increasing in recent years, probably due to the general introduction and cultivation of larger yielding varieties, such as the Siberian, American Banner, Ligowa, and Newmarket; and the adoption of better methods of farming. According to the reports of the Ontario Department of Agriculture, the average yield of oats per acre for the last ten years (1895-1904) is fully eleven per cent., or 3.8 bushels, higher than for the ten years previous (1885-1894).

Varieties of Oats. No less than two hundred and seventy-five different varieties of oats have been grown in our experimental grounds within the past sixteen years. The object in testing such a large number is to ascertain the few very best varieties which are most suitable for the different soils and localities throughout the Province. Eight of these varieties have now been grown under exactly similar conditions, without change of seed, for fifteen years in succession. The average results for the fifteen years in weight per measured bushel, yield of straw per acre, and yield of grain per acre are as follows:

| Varieties. | Weight per measured bushel. | Yield of straw per acre. | Yield of grain per acre. |
|---|---|---|---|
| | Pounds. | Tons. | Bushels. |
| Joanette | 35.5 | 3.0 | 90.5 |
| Siberian | 35.2 | 2.6 | 87.8 |
| Waterloo | 32.6 | 2.6 | 87,3 |
| Oderbrucker | 32.7 | 2.5 | 86.7 |
| Probsteier | 33.4 | 2.5 | 86.2 |
| Bavarian | 32.6 | 2.8 | 84.8 |
| Egyptian | 36.3 | 2.9 | 76.9 |
| Black Tartarian | 30.8 | 2.7 | 71.1 |

During the last five years in which these eight varieties have been grown side by side, we find the yield of grain per acre to be in the following order, starting with the highest yielding variety: Siberian, Waterloo, Probsteier, Oderbrucker, Bavarian, Joanette, Egyptian, and Black Tartarian. It must be remembered that these oats were grown on plots and not in large fields of each variety. The land on which they were grown, however, received no commercial fertilizers, but had an application of farmyard manure at the rate of twenty tons, which is about equal to twelve good-sized loads per acre, once every four years. Besides this, the land received one green crop plowed under within the last ten years. In a four years' rotation the Oats usually followed a cultivated crop which had been manured.

In the average results for five years in growing thirty-three varieties of oats, the varieties which have given high results, other than those already mentioned in the previous paragraph, are the Vick's American Banner, Canadian Pride, Peerless, Irish Victor, Liberty, Mennonite, Michigan Wonder and New Zealand. Among those grown for less than five years, the following are the largest yielders: Ertragreichster, Yellow Russian, The Great American, and the New Golden Cluster.

Seventy-eight varieties of oats were under experiment in 1904, and the results from the plots show that the following varieties produced the greatest yield of grain per acre: American Banner, Peerless, New Zealand, Irish Victor, Michigan Wonder, German Rust Proof, Black Gotham, Liberty, and The Great American. In weight of grain, only four varieties went as high as forty pounds per measured bushel, viz., Early Dawson, White Superior Scotch, Zhelannie, and Tobolsk.

In some localities, the oat crop lodges very badly before it is cut. In these sections, it is very important to obtain a variety which is very stiff in the straw and not so likely to lodge as some of the older varieties. According to the results of our experiments, the Tartar King and the Storm King are among the very stiffest straw varieties. These are apt to stand up where some of the other varieties will become badly lodged. We notice, however, that in extreme cases, where the Tartar King variety is grown and where it does become lodged, it usually lies very flat on the ground. The Storm King was grown in 1904 for the first time, and our experience, therefore, with this variety is still very limited. A variety obtained under the name of Canadian King is very similar to the Storm King, and may possibly be another name for the same variety.

According to the results of quite extensive experimental work at the College, we find that by growing oats and barley together a larger yield of grain can be obtained than from either one grown separately. In order to grow two grains together, however, it is important to select such varieties as will mature at about the same time. As nearly all varieties of oats are considerably later in maturing than most of the varieties of barley, it is important to select some very early variety of oats to use in combination with a six-rowed barley. The followir table gives the average results in number of days from seeding until maturity, strength of straw, weight per measured bushel, and average yield per acre of some of the very earliest oats we have grown at the College within the past three years :

| Varieties. | Number of days in reaching maturity. | Per cent. of crops lodged. | Average results for three years. | | |
|---|---|---|---|---|---|
| | | | Weight per measured bushel. | Yield per acre. | |
| | | | | Straw. | Grain. |
| | | | lbs. | Tons. | Bushels, |
| Daubeney | 98 | 5 | 34.5 | 2.3 | **95.7** |
| Alaska | 97 | 15 | 34.5 | 2.5 | **95.3** |
| Black Mesdag | 97 | 7 | 33.4 | 2.6 | **94.1** |
| Early White Pearl | 100 | 13 | 34.9 | 3.0 | **91.6** |
| Early Champion | 99 | 5 | 34.8 | 2.4 | **88.3** |
| Early Ripe | 95 | 22 | 28.7 | 2.3 | **81.3** |

It will be seen that the Daubeney variety is one of great promise, when the complete results are taken into consideration. The Daubeney variety grows a good length of straw, stand up very well, has a spreading head and white grain, and the grain is very thin in the hull.

Continuous Selection of Seed Oats for Twelve Years in Succession. For twelve years in succession, an experiment has been conducted in breeding oats by means of the selection of the seed. The selections made were large, plump, well-developed seeds: light-weighing and light-colored seeds; and also seeds from which the hulls had been removed by the separator. The test was commenced in the spring of 1903, by selecting seed from the general crop of the Joanette Black oats of the previous year. The selection made in each of the following years has been from the product of the selected seed of the previous year. The number of grains used on each plot was carefully counted and an equal number was used of each selection in each year. As the selection for this experiment has been continuous, selecting the seed each year from the crop produced in the year previous, the average results are of but little value, but the final results are interesting, valuable, and quite suggestive. In the crop produced in 1904, it was found that the large plump seed produced 94.1 bushels; the light seed, 68 bushels; and the hulled seed, 91.6 bushels per acre. As only the best quality of seed becomes hulled, we find that the oats from which the hulls had been removed gave nearly as good results as the carefully selected, large, plump seed from which the hulls had not been removed in the process of threshing. In weight per measured bushel, the crop produced from the large plump seed weighed 34.5 pounds; from the light seed, 24 pounds, and from the hulled seed, 33.1 pounds. The difference, therefore, between the large, plump, well-developed seeds and the light-weighing and light-colored seeds is very marked, and shows the great importance of sowing the former and discarding the latter. It is interesting to notice that the crop producing from the large plump seed required only 1390 grains to weigh an ounce; while the crop produced from the light seed required 2095 grains to make the same weight.

TREATMENT FOR SMUT IN OATS. Two varieties of oats were selected in the spring of 1902, 1903, and again in 1904, and uniform samples of each variety were submitted to several treatments, with the object of killing the spores of smut adhering to the grain. The various treatments were as follows:

(1). *Immersion in Diluted Formalin.* The solution of formalin used for the immersion process was made by pouring one-half pint of the formalin into 21 gallons of water, and the seed oats were immersed in the solution for twenty minutes.

(2). *Sprinkling with Diluted Formalin.* One-half pint of formalin was poured into 5 gallons of water. The oats were then sprinkled with this solution and carefully stirred until the grain was thoroughly moistened.

(3). *Immersion in Hot Water.* For this treatment, the grain was placed in a bag, which was then immersed in water at about 115 degrees F. Soon afterwards it was placed in water which was kept at a temperature of between 130 degrees and 135 degrees F. The grain was occasionally stirred, and was allowed to remain in the water for a period of fifteen minutes. It was then spread out on a clean floor to dry, where it was stirred occasionally.

(4). *Immersion in Bluestone Solution for Twelve Hours.* In this treatment, the bluestone solution was made by dissolving one pound of bluestone in 25 gallons of water, and the oats were immersed in this solution for a period of twelve hours.

(5). *Immersion in Bluestone Solution for Five Minutes.* For this treatment, a strong solution was made by dissolving one pound of Copper Sulphate (Bluestone) in one gallon of water, and then immersing the oats in the solution for a period of five minutes.

(6). *Immersion in Potassium Sulphide Solution.* The potassium sulphide treatment consisted in soaking the seed for two hours in a solution made by dissolving eight pounds of potassium sulphide in 50 gallons of water.

(7). *Sprinkling with Bluestone Solution.* This solution was made by dissolving one pound of bluestone in 10 gallons of water, which was used for sprinkling over the oats until they were thoroughly moistened after being carefully stirred.

(8). *Untreated.* One sample of oats of each variety was left untreated in order that the influence of the various treatments might be observed.

It will be seen that eight lots of each variety of oats were used in the experiment each year. After the treatments had been completed a few hours the oats were carefully sown on separate plots, each of which was exactly one rod square. When the oats were coming into head, they were examined frequently and all smutted heads removed and carefully counted. The following table gives the results in the percentage of smutted heads of oats in the average of the two tests in 1904, and also of the six tests in the three years during which this experiment has been conducted:

| Treatments. | Percentage of Smutted Heads. | |
|---|---|---|
| | 1904. | Average of 3 years. |
| Immersion in diluted formalin | .0 | .0 |
| Sprinkling with diluted formalin | .0 | .0 |
| Immersion in hot water | .0 | .0 |
| Immersion in bluestone solution for twelve hours | .0 | .2 |
| Immersion in bluestone solution for five minutes | .7 | 1.1 |
| Immersion in potassium sulphide solution | .3 | 1.3 |
| Sprinkling with bluestone solution | 1.4 | 1.4 |
| Untreated | 11.6 | 7.0 |

The results here presented are certainly worthy of careful consideration. It will be seen that in 1904 untreated seed had about 12 per cent. of smutted heads in the resulting crop. In the average results for the three years, there was a loss of seven per cent. caused by the injury by smut from the untreated seed. In comparison with this, we have the excellent results from the treatments with formalin and hot water. In the treatment with the stronger solution of formalin, however, which was sprinkled on the grain, the yield of oats per acre was less in 1904 in the case of each variety, as compared with other treatments. Taking everything into consideration, the immersion of the oats for twenty minutes in diluted formalin, made by using one-half pint of formalin with 21 gallons of water, has given excellent results The treatment is easily performed, comparatively cheap, and very effectual.

Influence on the Nurse Crop from Seeding Down with Timothy and Clover. In 1904 an experiment was conducted for the first time, with the object of ascertaining whether any direct advantage or disadvantage would result to a grain crop by sowing seed of Red Clover, Alsike Clover, and Timothy at the time of sowing the grain. No less than thirty-two plots were used for this experiment. The Siberian and the Joanette varieties of oats were each used on one-half the plots. Eight plots were seeded with Common Red Clover, eight with Alsike Clover, eight with Timothy, and eight plots were left without either grass or clover seed. The oats, Timothy seed, and clover seed germinated splendidly and the crops were very satisfactory in every case. In averaging the results, it is found that there is exactly 1.14 per cent. more oats where no grass or clover were sown than where the Timothy Alsike, and Red Clover were grown with the oats. It will therefore be seen, from the results of this experiment, that the practice of sowing grass and clover seed with the grain exerts but a very slight influence upon the yield of the grain crop.

SMUTTED OATS, ONE, TWO, THREE AND FOUR YEARS OLD FOR SEED PURPOSES. An experiment was conducted in 1904 for the first time, in order to ascertain whether the spores of smut on oats would be vital when two, three, or four years of age. For this experiment, the Black Tartarian and Daubeney varieties of oats were selected. Seed of each variety was taken from the crops of 1900, 1901, 1902 ,and 1903, and was sown on separate plots in the experimental grounds in the spring of 1904. These plots were watched very carefully, and, as any smutted heads appeared, they were removed from the plots and counted. The results show that as the seed increased in age there was a decrease in the yield of oats per acre and an increase in the perecentage of smutted heads. Further work will likely be carried out along this line.

WINTER OATS. Winter oats have been sown in our Experimental Department in the autumn of the year on several occasions, but the crop has always become badly winter killed. In the autumn of 1903, we sowed two varieties of winter oats, which made a good growth in the fall of the year but which were completely killed out during the winter. We have never yet been successful in getting a variety of winter oats which would withstand the severe winter weather at the College.

## WHEAT.

The wheat plant appears to have been known and valued from earliest times. It will thrive successfully in a great range of climate and the inhabitants of many countries enjoy the advantages of its cultivation. According to most authorities, there are in all seven types of wheat, and to one or the other of these types, or species, all varieties belong. The seven types of wheat are as follows :

(1) Common, fine, or soft wheat (*Triticum vulgare*).
(2) Turgid, or toulard wheat (*T. turgidum*).
(3) Hard or flinty wheat (*T. durum*).
(4) Polish wheat (*T. polonicum*).
(5) Spelt (*T. spelta*).
(6) Emmer or starch wheat (*T. dicoccum*).
(7) One-grained wheat (*T. monococcum*).

Representatives of these different classes have been grown in our experimental grounds, although practically nothing is known throughout the Province about varieties of either turgid or one-rowed wheat. Considerable, however, has been said in reference to representatives of each of the other classes. Nearly all of the varieties of both spring and winter wheat which are grown in Ontario belong to type No. 1, the common wheat. Some of the best known representatives of other types are as follows : Wild Goose spring wheat, Medeah spring wheat, Algiers spring wheat, Polish spring wheat, Miracle winter wheat, etc. For the sake of convenience, we have arranged our report of varieties of wheat as follows: Varieties of winter wheat for flour production, varieties of spring wheat for the production of macaroni, and varieties of spring wheat for feeding purposes.

Varieties of Winter Wheat for Flour Production. The past year has been an unfavorable one for winter wheat production in Ontario, According to the last report of the Bureau of Industries, we learn that no less than 189,274 acres, or nearly 24 per cent., of the area sown to winter wheat last autumn, was plowed in the spring of 1904. Some of the varieties in the experimental grounds at the College survived the winter in good condition; while some of the tender varieties were considerably winter killed.

Within the past fifteen years, about two hundred varieties of winter wheat have been grown at the College. The most of these have been grown for at least five years in succession. The highest yielding varieties for the past five years, including 1904, have produced the following average number of pounds of grain per measured bushel, and of bushels of grain per acre: Dawson's Golden Chaff, 59.9 lbs., 59.8 bus.; Imperial Amber, 61.2 lbs., 58 bus.; Prize Taker, 59.8 lbs., 57.6 bus.; Silver Dollar, 59.7 lbs., 57 bus.; Buda Pesth, 61.4 lbs., 55.4 bus.; Rudy, 61.1 lbs., 55.4 bus.; Forty-fold, 59.1 lbs., 55.4 bus.; and Egyptian Amber, 61.4 lbs., 55.2 bushels. The greatest yielders among seventy-two varieties grown in the past year, however, were the Imperial Amber, 41.3 bus.; Buda Pesth, 40 bus.; Crimean Red, 39.9 bus.; Rudy, 38.1 bus.; Tasmania Red, 36 bus.; Dawson's Golden Chaff, 35.7 bus.; and Egyptian Amber, 35 bushels per acre. The weight per measured bushel for this season has been exceptionally light, as can be seen from the following: Tasmania Red, 58.6 lbs.; Imperial Amber, 57.6 lbs.; Dawson's Golden Chaff, 55.7 lbs.; Turkey Red, 55.5 lbs.; and Early Genessee Giant, 52.3 pounds. The Dawson's Golden Chaff possessed the stiffest straw and the Red Hussar the weakest straw in 1904. All varieties rusted more or less in 1904, the Ironclad, Tasmania Red, and Pride of America being the freest. The Hessian fly did only a small amount of damage the past year.

Varieties of Spring Wheat for Flour Production. Spring wheat throughout Ontario seemed to give promising results until about the time of ripening, when the rust attacked the straw considerably, and the weather conditions seemed unfavorable for the production of a plump sample. In some sections the spring wheat was an utter failure. In the experiments at the College, most of the varieties gave a fair yield per acre, but the quality was unusually poor, as nearly all of the varieties came considerably under the standard in weight per measured bushel.

Eleven varieties of flour producing spring wheats have been grown in the Experimental Department under similar conditions for six years in succession. In the average results for the six years, the varieties here referred to have given the following yields per acre: Pringle's Champion, 35.1 bus.; Saxonka, 34.8 bus.; Red Fife, 34.5 bus.; Colorado, 34.1 bus.; Blue Democrat, 34 bus.; Preston, 33.5 bus.; White Russian, 33.3 bus.; Wellman's Fife, 33.1 bus.; Red Fern, 33.1 bus.; Herison Bearded, 32.2 bus.; and Seven Headed, 30.1 bushels. Of the newer varieties which have been under experiment for only three years, the following are among the heaviest yielders: Kolben, 28.9 bushels, and Climax, 25.4 bushels

Varieties of Spring Wheat Suitable for the Production of Macaroni. Those varieties of spring wheat suitable for the production of macaroni mostly belong to type No. 3, viz., the hard or flinty wheat (*T. durum*). Some seven varieties in all have been grown at the College for several years in succession. The average results of six years' experiments with six of these varieties are as follows:

| Varieties. | Weight per measured bushel. | Yield of straw per acre. | Yield of grain per acre. |
|---|---|---|---|
| | Lbs. | Tons. | Bushels. |
| Wild Goose | 62.0 | 2.3 | 42.1 |
| Medeah | 59.8 | 2.4 | 38.6 |
| Sorentina | 59.2 | 2.3 | 38.4 |
| Bart Tremenia | 60.1 | 2.3 | 37.3 |
| Algiers | 58.8 | 2.3 | 36.6 |
| Ontario | 55.1 | 2.9 | 29.0 |

It will be seen from the average results of the macaroni wheats for six years, that the Wild Goose variety has given the largest yield of grain per acre, and also the heaviest weight of grain per measured bushel. In the average results for 1904, the greatest yields were produced by the Wild Goose and the Medeah, and the lowest by the Ontario variety.

Another wheat which has been grown more or less in Egypt, Algiers, Spain, Italy, and Eastern Europe, and to a very limited extent in America, and which has been used to a greater or less extent for the manufacture of macaroni, is the representative of the species *Triticum polonicum*, and is known under such names as Polish Wheat, Corn Wheat, Colorado Giant Rye, etc. Many extravagant claims have been made for this grain in the Western States within the last two years. The straw of this variety is of medium length and is almost solid. The heads are large, and the outer chaff projects beyond the inner chaff in a peculiar manner. The grains are very hard and are about one and a half times as large as those of the Wild Goose spring wheat. We first grew the Polish wheat at the College in 1889. Careful tests of its comparative results, along with other varieties, have been made for at least ten years. In the average of the ten years' experiments, we find that the yield per acre of the Polish wheat is 22.1 bushels, and that of the Wild Goose 36.3 bushels per acre. The Wild Goose variety, therefore, gave an average yield of about 60 per cent. more than that of the Polish wheat.

According to the results of the experiments made with different macaroni wheats at the College, it will be seen that the Wild Goose variety has given the most satisfactory results in yield of grain per acre. This variety is exceedingly hard and contains a large amount of gluten. The flour produces bread of excellent quality but which is of a yellowish color, which gives it an unattractive appearance. As the wheat is very hard, it is difficult to grind, but many millers are now using a limited quantity of the flour of the Wild Goose variety to strengthen that of some of the softer kinds of both winter and spring wheats. A considerable amount of the Wild Goose spring wheat has been shipped to Italy, and to other parts of Europe, for the manufacture of macaroni, and it is largely that demand which has increased the price of the Wild Goose spring wheat in Ontario during recent years.

Varieties of Spring Wheat for Feeding Purposes. Emmer and Spelt are two distinct types of wheat, there being a number of varieties belonging to each type. The grain of both the Emmer and the Spelt is tightly enclosed within the chaff, from which only a small portion is separated in the process of threshing. The heads of Emmer are short and compact, and are nearly always bearded; while those of Spelt are long, narrow, open, and are usually bald. The spikelets of Emmer overlap each other like shingles on a roof, which thus makes the head close, smooth, and regular. The portion of the stem adhering to the spikelets after threshing is much smaller and more pointed in the Emmer than in the Spelt. The spikelets of the Emmer are flattened on the inner side, while those of the Spelt are arched. The grain of the former is much harder, and the chaff much softer, than that of the latter. Emmer is considered a very hardy plant, being much superior to Spelt in this respect. Three varieties of Emmer and ten varieties of Spelt have been grown in the Experimental Department of the College. The following table gives the average of three years' results of each of three of the principal varieties of Emmer and four of the principal varieties of Spelt which were tested in 1902, 1903, and 1904:

| Classes of Crop. | Varieties. | Average results for three years. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Percentage of | | | Pounds per bushel 2 years. | Yield per acre. | |
| | | Rust. | Crop lodged. | Hull with grain. | | Tons of straw. | Pounds of grain. |
| Emmer | Common | 3 | 36 | 22 | 36.8 | 2.7 | 3,467 |
| | Iowa | 2 | 36 | 21 | 37.3 | 2.4 | 3,248 |
| | Russian | 2 | 34 | 22 | 36.3 | 2.3 | 3,204 |
| Spelt | Red | 20 | 6 | 32 | 25.4 | 2.2 | 2,364 |
| | Alstroum | 20 | 4 | 33 | 24.4 | 2.0 | 2,164 |
| | White | 19 | 5 | 34 | 23.7 | 1.7 | 1,895 |
| | Dasyanthum | 23 | 25 | 40 | 22.6 | 2.1 | 1,637 |

It will be seen from the foregoing table that all the varieties of Emmer have given decidedly better results than the best varieties of Spelt which we have grown. In the co-operative experiments throughout Ontario in 1901, 1902, 1903, and 1904, Emmer produced a larger average yield of grain per acre than the best variety of oats or the best variety of barley which was distributed. It is quite probable that the Emmer will be grown considerably throughout Ontario for the production of good, clean straw and a large yield of grain, to be used as a food for live stock. For feeding purposes, the grain and the surrounding chaff are usually ground together in the same manner as oats are ground into meal.

Sowing Emmer and Spelt on Different Dates. Both Emmer and Spelt were sown on eight different dates in the spring of 1903, and again in the spring of 1904, starting on April 2nd in 1903 and on April 22nd in 1904, and finishing on May 21st in 1903 and on June 10th in 1904, and allowing one week between each two dates of seeding. The average results of the experiment for two years are presented in tabulated form.

| Dates of Seeding. | Average results for two years. | | | | | |
|---|---|---|---|---|---|---|
| | Lbs. per measured bushel. | | Tons of straw per acre. | | Lbs. of grain per acre. | |
| | Spelt. | Emmer. | Spelt. | Emmer. | Spelt. | Emmer. |
| 1st | 28.0 | 38.3 | 1.8 | 2.1 | 2,393 | 2,058 |
| 2nd | 26.1 | 38.0 | 1.5 | 2.1 | 1,993 | 3,038 |
| 3rd | 25.6 | 38.0 | 1.7 | 1.9 | 1,829 | 2,827 |
| 4th | 24.4 | 37.6 | 1.6 | 2.1 | 1,354 | 3,010 |
| 5th | 23.9 | 37.6 | 1.6 | 2.2 | 1,277 | 3,094 |
| 6th | 23.2 | 37.2 | 1.7 | 2.4 | 1,010 | 2,836 |
| 7th | 22.1 | 36.8 | 1 5 | 2.8 | 795 | 2,782 |
| 8th | 24.1 | 35.5 | 1.6 | 2.1 | 577 | 2,332 |

The average results of the experiment in sowing Emmer and Spelt in 1903 and 1904, on the average dates of April 12th, April 19th, April 26th, May 3rd, May 10th, May 17th, May 24th, and May 31st, show that decidedly the best yield of Spelt was obtained from the first seeding; while there was but little difference in the yield per acre of the Emmer sown on the 1st, 2nd, 4th, and 5th dates. The figures indicate the great importance of sowing Spelt as early in the spring as the land is warm and dry enough to work to good advantage. In the case of Emmer, however, comparatively late seeding gives about as good results as the seeding which takes place at an early date. The figures of this report, as well as those in the report of the varieties of Emmer and Spelt given previously, show very forcibly the superiority of the Emmer over the Spelt as a grain producer in this section of the Province.

Maturity of Winter Wheat for Seed Purposes. Seed taken from wheat which was allowed to become very ripe before it was cut produced a greater yield of both grain and straw and a heavier weight of grain per measured bushel than that produced from wheat which was cut at any one of four earlier stages of maturity, according to the average results of fourteen separate tests.

Selection of Seed. Selections of seed made from two varieties of winter wheat and tested for six years produced average annual results in bushels of grain per acre, tons of straw per acre, and pounds per measured bushel as follows:. Large plump seed, 46.9 bushels, 2.6 tons, and 59.4 pounds; Small plump seed—40.4 bushels, 2.2 tons, and 59.2 pounds; Shrunken seed—39.1 bushels, 2.1 tons, and 59.1 pounds; and Broken seed—9.3 bushels, .6 tons, and 54.2 pounds, respectively.

Quality of Winter Wheat to Sow. The average yield, less the amount of seed used, from sowing one bushel, one and one-half bushels, and two bushels of each of two varieties of winter wheat per acre in each of six years, have been 39.7 bushels, 42.3 bushels, and 42 4 bushels per acre, respectively.

Southern and Northern Grown Winter Wheat Seed. Seed wheat grown a thousand miles south of Guelph gave practically the same results as Ontario grown seed in the average experiments of two years.

Dates of Sowing Winter Wheat. Winter wheat sown at the College during the first ten days of September in each of nine years has yielded 5.2 bushels per acre more than that sown from the 16th to the 20th of September.

Methods of Sowing Winter Wheat. The average results of sixteen experiments, covering a period of eight years, show that on well cultivated land winter wheat which was drilled in with a machine, and that which was sown broadcast by hand, gave practically the same yields of grain per acre.

Green Manuring for Winter Wheat. Land on which field peas were used as a green manure yielded 6.5 bushels of wheat per acre more than land on which buckwheat was used as a green manure, and 2.3 bushels per acre more than land which was worked as a bare fallow, in the average of eight separate tests.

Treatment of Winter Wheat for Smut. In each of five years, experiments have been conducted in treating winter wheat in different ways to kill the stinking smut, and the results have been very satisfactory. In the autumn of 1903, seven different treatments were made with each of two varieties of wheat. In the crop of the present year, the wheat produced from treated seed had no smut, and that from untreated seed had 3.6 per cent. of smutted heads. The treatment which proved very simple, cheap and effective was the immersion of the seed wheat for twenty minutes in a solution made by adding one pint of formaldehyde (formalin) to forty-two gallons of water. The past year was the first time that we used the formalin treatment as a part of this experiment. In the average of five years' experiments, it was found that untreated wheat had 368 smut balls per pound of wheat; while that treated with potassium sulphide, bluestone, and hot water had only nine, two, and one smut balls, respectively. The copper sulphate (bluestone) treatment consisted in immersing the seed twelve hours in a solution made by dissolving one pound of copper sulphate in twenty-four gallons of water, and then immersing the seed for five minutes in lime water made by slacking one pound of lime in ten gallons of water. The hot water treatment consisted in immersing the wheat for fifteen minutes in water at 132 degrees F. After each treatment, the grain was spread out and stirred occasionally until dry enough to sow.

## Rye.

Rye can sometimes be grown advantageously in those districts in which the soil is unsuited for other cereal crops. It is the characteristic food-grain of middle and northern Europe, and is used extensively by fully one-third of the population of Europe.

Winter Rye. Several varieties of winter rye have been grown in our experimental plots for a number of years with good success. In the autumn of 1903, five varieties were sown in the same section of the field as the winter wheat. They all came through the winter well, surpassing many of the varieties of winter wheat in this respect. In five years' experiments with two varieties of winter rye, we find that the Mammoth gave an average yield of 60.5, and the Common variety of 57.8 bushels per acre. These are very large yields, showing that winter rye is a very hardy crop,withstanding the severity of even some of the severe winters which we have had within the past five years. In the experiments for 1904, the Mammoth gave 56.4; and the Common, 55.5; the Thousand-fold, 54.8; and the Washington variety, 51.8 bushels of grain per acre. It will therefore be seen that the Mammoth variety produced a greater yield per acre in 1904, and in the average of the past five years.

Spring Rye. Four varieties of spring rye were grown in our experimental plots in the past season, the following being the results in yield of grain per acre: Dakota Mammoth, 34.9 bus.; Prolific Spring, 26.7 bus.; Common, 24.7 bus.; and Saatroggen, 24.3 bushels. Two of these varieties have been grown for seven years in succession, and the average results have been as follows: Dakota Mammoth, 38.8 bushels, and Prolific Spring, 35.1 bushels per acre. It will therefore be seen that among the spring varieties, the Dakota Mammoth has given very satisfactory results in yield of grain per acre. This variety has also produced slightly the heaviest weighing grain per measured bushel, the average for seven years being 57.4 pounds.

## Buckwheat.

Buckwheat is a native of Northern Asia, and has been grown as a cultivated crop for fully one thousand years. It grows and produces a marketable crop on very poor soil, and it thrives admirably in cold climates. It is mainly grown for the production of grain, but it is also grown to a limited extent for soiling purposes and for plowing under as a green manure.

We have grown eight varietites of buckwheat in our experimental grounds within the past few years. Three varieties, namely, the Japanese, the Silver Hull, and the Common Grey, have each been grown in our trial grounds for eight years in succession. In the average results for the eight years, we find that the Silver Hull variety takes the lead with 20.2 bushels per acre. This, however, is closely followed by the Japanese variety, which produced a yield of 19.7 bushels per acre. The Common Grey, under similar conditions, gave only 16.6 bushels per acre. The last two or three years have been very unfavorable for the Japanese variety. According to the experiments conducted both at the College and throughout Ontario, the Japanese buckwheat appears to give the best results in seasons which are comparatively warm and dry; and the Silver Hull variety in cool, damp seasons such as we have had in 1902, 1903, and 1904. The results for the last year are quite different from the average of the last eight years, the following being the yield per acre of each variety: Japanese, 11.7 bushels; Silver Hull, 37.5 bushels; and Common Grey, 20.3 bushels per acre. Therefore, in the past season, the Silver Hull variety has yielded more than three times as much as the Japanese buckwheat. The Silver Hull variety possesses very plump grain, which is thin in the hull and weighs well per measured bushel.

## Field Peas.

The common field pea is a leguminous plant and a native of Italy. It has been in cultivation many hundred years, and is chiefly grown for its grain. It is also used in mixing with oats for the production of green fodder or hay. For soiling purposes, it produces a large yield of very nutritious food, but when fed alone is not generally relished by farm stock. The seed is exceptionally rich and is of great value for using with other grain in fattening cattle and hogs. The straw is used extensively as a food for sheep, and is sometimes mixed with other coarse fodder for feeding to dairy cows. Field peas are sometimes used as a green manure with very excellent satisfaction.

Owing to the ravages of the pea weevil (*Bruchus pisorum*), frequently called the pea bug, the acreage of peas has been greatly reduced in Ontario during the past six or seven years. In many sections of the southwestern part of the Province, the farmers have given up the growing of peas entirely for a time, owing to the great damage caused by the pea weevil. As the acreage has been reduced to such a large extent, we would very strongly advise any persons who grow peas in the southwestern part of Ontario in 1905 to cut the peas a little on the green side, then cure and thresh them as soon as possible, and immediately treat them with carbon bisulphide. Within a period of seven years, about thirty different treatments of peas were made in the Experimental Department for the destruction of the pea weevil. In handling the crop, care was taken throughout to pull the peas at the proper time, to haul them to the barn when dry, and to thresh them as soon as possible. Immediately after threshing, the peas were put into cotton or jute bags. As soon as thirty bushels of peas were threshed, they were placed in a fumigation box for treatment. One pound of carbon bisulphide was poured into three flat pans, which were placed on the top of the peas; the cover was then put on the box and weighted with heavy stones. After forty-eight hours the cover was removed and the box ventilated. The pans had become dry, as the liquid had changed into a gas, which, being much heavier than air, had sunk down amongst the peas penetrating them and killing the weevils. The quantity of carbon bisulphide used by us was larger than that usually recommended, as a pound or a pound and a half is generally considered sufficient for one hundred bushels of peas, but we wished to be on the safe side. In practically all cases the weevils were destroyed at the first treatment, no matter whether they were in the larva form, in the pupa stage, or had become fully developed. The treatment can be made in any comparatively air-tight receptacle, whether a barrel, box, or specially made fumigation house.

Carbon bisulphide is a colorless or slightly yellowish liquid, one-fourth heavier than water. It is extremely volatile, i. e., it evaporates very rapidly when exposed to the air, and when pure will not injure or stain the finest goods. The commercial liquid has an acrid taste, and an odor like that of rotten eggs. The vapor is more than two and a half times as heavy as air. Carbon bisulphide may be purchased in small quantities from any druggist at about 30 cents per pound, or 40 cents per pint. For large quantities, better rates can be given by the druggist. The gas, or vapor, which comes from carbon bisulphide is not only combustible, but it is very explosive when mixed with air. Great care should therefore be taken to treat the peas in the daytime only, for a light or a flame of any kind brought near the liquid may cause a serious explosion; and smoking near it should be positively prohibited. Moreover, the vapor should not be inhaled, as it is very injurious, even a small portion causing headache, giddiness, and nausea. The treatment with carbon bisulphide should be made in boxes, barrels, or "bug houses," located some distance from the insured buildings on the farm.

With the strict observance of the preceding precautions, no one should hesitate to use the carbon bisulphide. As a matter of fact, we have never heard of any bad results following its use in the treatment of peas. This happy condition of things may be explained when we say that all who used the liquid were wise enough to be cautious. There is, moreover, no danger that the vapor will injure the peas or render them unsafe as a food. Experiments have shown that the liquid can even be poured upon articles of food, and, after thorough exposure to the air, not a trace of it will remain.

There is as yet but little trouble from the pea weevil in the extreme eastern and northern portions of the Province, where peas can still be grown to good advantage. Although we have not made comparative tests of different varieties of peas in our experimental grounds during the past two years, a reference might here be made to the results of former experiments. Fully one hundred varieties of field peas have been grown in our experimental plots within the past fifteen years. For a very rich soil, the White Wonder gave the greatest yield of rgain per acre; for a soil of medium quality, the Early Britain gave a very high yield, and the New Canadian Beauty gave a moderately high yield of seed of excellent quality; and for poorer soils, the Prussian Blue and the Tall White Marrowfat, which are both very long strawed varieties, gave excellent results.

Although we have mentioned previously that no comparative experiments of different varieties of field peas have been conducted during the past two years, the Early Britain variety was grown and ripened in 1904, and was carefully examined in order to ascertain the ravages of the pea weevil. As determinations regarding the percentage of weevilly peas of this variety have been made since 1894, the percentage of crop infested with the weevils each year gives us some information regarding the ravages of this pest in this section of the Province. The following gives the percentage of weevilly peas of the Early Britain variety for each of the eight years: 1894, 2; 1895, 7; 1896, 11; 1897, 34; 1898, 49; 1900, 75; 1901, 96; and 1904, 61 per cent. It will therefore be seen that the damage caused by the pea weevil in 1904 was only about two-thirds as great as it was three years ago. As the farmers in the vicinity of Guelph have stopped growing peas to a considerable extent within the past two years, the ravages of the pea weevil seem to be somewhat reduced.

## Field Beans.

Field beans are not grown very extensively throughout Ontario, except in the southwestern part, and especially in the counties of Essex and Kent. Fourteen varieties of beans were under experiment in cur trial grounds at the College in 1904. The yields were comparatively low this season, probably due to the cold, wet weather in this part of the Province. The seven highest yielding varieties in the past season were: New Prize Winner, 17.4 bushels; Schofield Pea, 16.6 bushels; White Wonder, 15.3 bushels; Small White Field, 15.3 bushels; Burlingame Medium, 14.8 bushels; the Pearce's Improved Tree, 14.8 bushels per acre. In the average results for eight years of thirteen varieties of beans, which have been grown for that length of time, we find that those varieties which gave the greatest yields per acre were the White Wonder, 21.8 bushels; Pearce's Improved Tree, 21.3 bushels; Burlingame Medium, 20.8

bushels; Medium or Navy, 20.7 bushels; and Schofield Pea, 20.5 bushels per acre. In average weight per measured bushel for eight years, there was a variation from 57 pounds for the Large White Haricots to 65.7 pounds for the Snowflake variety. Twelve out of the thirteen varieties, however, gave upwards of 62 pounds per measured bushel in the average of eight years' experiments.

### Soy, Soja, or Japanese Beans.

Many of the varieties of Soy beans require too long a season to give satisfactory results in Ontario. As the result of experiments conducted for a series of years, however, we have found the Early Yellow variety to give good satisfaction as a grain producer, and the Medium Green variety as a fodder crop. We believe that as the Medium Green variety becomes better known, it will be grown for the purpose of cutting green and mixing with corn when filling the soil. We also believe that the Early Yellow variety can be grown quite successfully for grain production on many farms of Ontario. The grain is exceedingly rich, containing more protein than any of the ordinary farm crops grown in Ontario. A small quantity of the Soy beans, ground and mixed with other meal, will increase the quality of the meal considerably. Owing of the unfavorable weather conditions for the Soy beans in 1904, the crop was not as satisfactory as usual. We generally get about 1,200 pounds of grain per acre, but the best yielding variety of Soy beans in 1904 produced only 880 pounds of the ripened seed per acre.

### Horse Beans.

The Horse bean is a coarse, rank-growing annual legume which is used quite extensively in Europe as a forage plant. There are several named varieties of horse beans, a number of which have been grown at the College. They have been under test in the Experimental Department for practically each season during the past fifteen years. In most seasons, they give very poor results. The yield of ripe seed in 1904 was only 200 pounds per acre. On the whole, the Horse beans seem to be unsuited for general cultivation throughout Ontario.

### Grass Peas.

The Grass pea is a leguminous plant, which produces long, flat vines; slender leaves; white blossoms; medium-sized pods; and hard, angular, white, or greenish white, grains. It is entirely proof against the attacks of the pea weevil. In many respects, it resembles the Bitter Vetch (*Lathyrus sativus*) of Europe, which, however, has blue flowers and brown seeds. It also appears to be free from the poisonous principle which the Bitter Vetch is said to possess. This is borne out by the extensive and satisfactory use of the Grass peas as a food for farm stock.

In the average results of tests made for a period of seven years, it was found that the annual yield of grain was 25.7 bushels, and the yield of straw 2.2 tons per acre. During the last two or three years, however, the seasons have been very unfavorable for the growth of the Grass peas, as they have for practically all kinds of leguminous crops. The yield per acre of Grass peas at the College in 1904 was only 992 lbs., or about 16 1-2 bushels per acre.

### Cow Peas.

The Cow peas, which thrive so admirably in the southern States, require a comparatively long season from the time they are sown until they reach maturity. We have tested a large number of varieties, no less than ten being under experiment in 1904. We have as yet been unable to secure any varieties of Cow peas which have given satisfactory results at the College.

### Hairy Vetches for Seed.

For four years in succession, Hairy vetches have been sown in the autumn and ripened in the following year, with the result that an average of 8.6 bushels of seed per acre has been obtained. The vetches sown in the autumn seem more productive of seed than those sown in the spring of the year In past years, the Hairy vetch seed has been principally imported from Germany, and has usually cost about $5.00 per bushel. The Hairy vetches produce a crop which seems specially useful as a pasture for farm stock, especially hogs; a cover crop in orchards; or a green manure for plowing under to enrich the soil.

### Alfala for Seed Production.

For three years in succession, efforts have been made to produce Lucerne or Alfalfa seed in the experimental plots at the College. Owing, probably, to the unfavorable weather conditions, the yield of seed has been rather light in each of the three years.

### Corn for Grain.

Owing to the cool, wet weather of the past season, corn for grain production gave a very poor crop. At the usual time of corn planting, the weather was cool and the land too wet to plant corn. Consequently, the seed was not planted until the early part of June. The growth throughout the season was rather slower than usual, and the first nipping frost occurred comparatively early this season, thus preventing the maturity of those varieties which usually ripen quite well at Guelph. The names of some of those varieties which gave the best satisfaction in 1904 are as follows, commencing with the best corn: King Phillip, Wisconsin Little Dent, Genessee Valley, Red Blazed, Extra Early Huron Dent, Farmers' Friend, Farmers' Surprise, University No. 13, Longfellow, Early Strawberry, Compton's Early, Golden Leneway Dent, Salzer's North Dakota, Tuscarora, and King of the Earlies. For the four years previous to 1904, the average yields per acre for the highest yielding varieties of corn for grain production were as follows: King Phillip, 58 bus.; Farmers' Friend, 54 bus.; Longfellow, 54 bus.;

Genessee Valley, 53 bus.; Canada Yellow, 48 bus.; Red Blazed, 47 bus.; Burlington Hybrid, 45 bus.; Salzer's North Dakota, 43 bus.; and Compton's Early, 42 bushels per acre. The King Phillip variety, which came at the top of the list in 1904, and also in the average of the four years previous, is a reddish flint variety which we have sent out in connection with the co-operative experiments over Ontario for the last two or three years. It has given very good satisfaction throughout the Province, giving the largest yield of grain per acre over Ontario in 1904.

### Sorghum for Seed.

Several varieties of sorghum, including different kinds of sugar cane, kaffir corn, broom corn, millo maize, etc., have been grown in the experimental grounds from year to year. Owing to the cool, backward season, however, none of the varieties ripened seed satisfactorily in 1904.

### Millet for Seed.

In the average results for five years, in testing fifteen varieties of millet for seed production, it is found that the Siberian Millet (47.5 bus.) Hungarian Grass (45.2 bus), and the California Millet (42. 1bus.), have been the heaviest yielders. These, however, have been quite closely followed by the German or Golden (38.8 bus.) and Early Harvest (38.7 bushels per acre). In comparison with these, it might be mentioned that the lowest yields were obtained from the White French, 14 bus.; Golden Wonder, 18.5 bus.; and the Red French, 19.3 bushels per acre. In the results of testing twenty-one varieties in 1904, we find the greatest yields produced by the Siberian Millet, Steel Trust Millet, Hungarian Grass, California Millet, German or Golden Millet, Early Harvest Millet, and Tamboy Millet.

### Sunflower Seed.

Seven varieties of sunflowers have been grown in the experimental grounds. Three of these varieties have now been grown for six years in succession. Allowing 20 pounds for the measured bushel, the average results for the six years are as follows: White Beauty, 68.7 bus.; Mammoth Russian, 65.5 bus.; and Black Beauty, 57.8 bushels per acre. It will thus be seen that all the varieties have produced heavy yields of seed per acre, and of the three leading varieties the White Beauty has given excellent satisfaction, producing an average yield of 1,374 pounds of seed per acre per annum.

### Flax Seed.

Four varieties of flax have been grown in the Experimental Department. The common variety has now been under experiment for nine years, the average yield per acre for the whole period being 13.5 bushels of grain. The yield of flax at the College has been very low in some seasons, and this has brought the average down to the figures here given. In 1904 the common flax gave a yield of a little over 21 bushels of seed per acre.

### Sowing Spring Grain on Six Different Dates.

Not only is it important that we give proper attention to the varieties of seed which we sow and to the careful selection of the seed, but it is also of very great importance to have the seed sown at exactly the right time in the spring of the year. In order to obtain some reliable and specific information regarding the actual results of sowing grains at different times in the spring of the year, an experiment has been conducted at the College in each of five years by sowing spring wheat, barley, oats, and peas, on each of six different dates in the spring. The experiment was conducted in duplicate each season. The first seeding took place when the land was warm enough and dry enough to work to good advantage. One week was allowed between each two seedings, unless unfavorable weather compelled a change of a day or two in the date of seeding. The average date of the first seeding was April 18th, and of the last seeding May 23rd. The average results of this experiment are reported in the accompanying table and are illustrated in the accompanying diagram. The average results for the five years in per cent. of rust, in weight of grain per measured bushel and in yield of straw and of grain per acre for each of the four classes of grain and for each of the six different dates of seeding of each kind of grain will be found in the table here given :

| Class of crop. | Seeding. | Per cent. of rust, average 4 years. | Average results for five years. | | |
|---|---|---|---|---|---|
| | | | Weight per measured bushel. | Yield of straw per acre. | Yield of grain per acre. |
| Spring wheat.......... | 1st seeding ............... | 4.5 | 60.1 | 1.22 | 21.9 |
| | 2nd " ...... ...... | 5.5 | 59.6 | 1.13 | 19.2 |
| | 3rd " .............. | 5.3 | 59.0 | .97 | 15.4 |
| | 4th " .............. | 7.8 | 58.9 | .87 | 13.0 |
| | 5th " .............. | 8.5 | 56.5 | .63 | 8.4 |
| | 6th " .............. | 11.3 | 54.0 | .77 | 6.7 |
| Barley ................ | 1st " .............. | 4.0 | 52.3 | 1.20 | 46.2 |
| | 2nd " .............. | 4.3 | 52.6 | 1.19 | 45.9 |
| | 3rd " .............. | 5.5 | 51.8 | 1.05 | 39.8 |
| | 4th " .............. | 6.3 | 50.3 | 1.04 | 37.1 |
| | 5th " .............. | 11.8 | 48.2 | .94 | 27.6 |
| | 6th " .............. | 14.0 | 45.1 | .85 | 18.4 |
| Oats .................. | 1st " .............. | 10.8 | 33.9 | 2.00 | 75.2 |
| | 2nd " .............. | 15.8 | 34.5 | 2.10 | 76.0 |
| | 3rd " .............. | 19.3 | 32.1 | 1.83 | 64.2 |
| | 4th " .............. | 25.0 | 29.9 | 1.72 | 55.8 |
| | 5th " .............. | 25.3 | 27.3 | 1.56 | 45.2 |
| | 6th " .............. | 23.8 | 24.2 | 1.72 | 37.0 |
| | | Per cent. of weevilly peas, average 2 years. | | | |
| Peas .................. | 1st " .............. | 43.5 | 56.6 | .92 | 25.4 |
| | 2nd " .............. | 56.0 | 56.6 | 1.07 | 28.8 |
| | 3rd " .............. | 49.0 | 57.6 | 1.10 | 28.5 |
| | 4th " .............. | 54.5 | 57.4 | 1.02 | 25.5 |
| | 5th " .............. | 59.5 | 57.0 | .87 | 21.5 |
| | 6th " .............. | 57.0 | 57.0 | .95 | 19.5 |

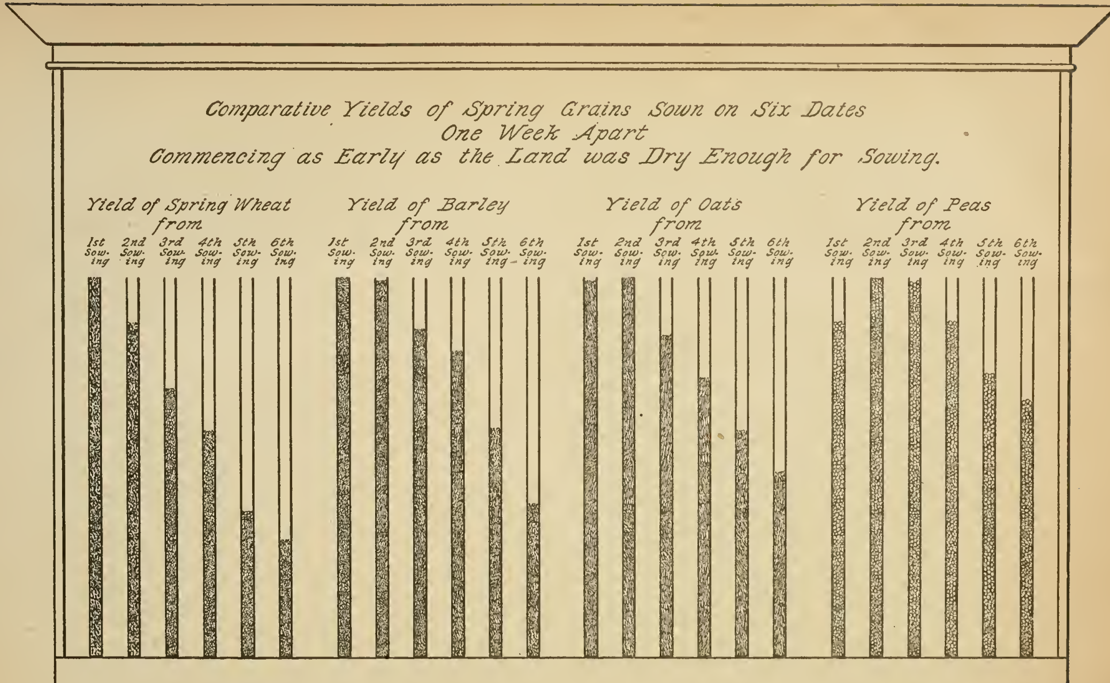


Diagram Illustrating one of the Cases in the Agricultural Museum at the College, Showing the Average of Five Years' Results in Sowing Spring Grains at Different Dates.

The results here presented show that the greatest average yield of grain per acre was produced by the spring wheat and by the barley from the first, and by the oats and the peas from the second date of seeding. This also holds good in regard to the straw per acre, with the single exception that in the case of peas the seed sown on the third date produced a little higher yield than that sown on the second date. In weight of grain per measured bushel, the first two dates of seeding are decidedly the best with spring wheat, barley, and oats, but in the case of peas the highest weights of grain per measured bushel were obtained from the third and fourth seedings. It will be observed that as the date of seeding was delayed the percentage of rust in the resulting crop was gradually increased, with only one slight exception. The results indicate the importance of sowing spring wheat, barley, oats, and peas in the order here given, starting with the spring wheat and finishing with the peas.

An exceedingly important lesson may be learned from the results of this experiment, which show that for every day's delay in the seeding after the first week was passed in which the seeding took place, there was an average decrease of 56 lbs. of oats, 53 lbs. of barley, 29 lbs. of spring wheat, and 23 lbs. of peas per acre.

## Growing Grains in Mixtures for the Production of Grain and Straw.

Within the past fifteen years, a large amount of experimental work has been carried on in order to glean some reliable information regarding the comparative values of growing grains in combination in comparison with the growing of the same grains separately for the production of grain and straw. Some of the experiments have been completed, while others will need to be repeated in future seasons before the final conclusions can be drawn. The results of the experiments already conducted are very interesting and quite suggestive.

Four Kinds of Spring Grain Grown Separately and in Various Combinations. For five years in succession, an experiment was conducted in growing peas, oats, barley, and wheat, separately, and in all the combinations which could be formed, having two, three, or four grains in each mixture. This formed an experiment of fifteen different crops, which were grown in comparison one with the other. The experiment was conducted in duplicate each year. The results go to show that the grain which was grown in mixtures produced larger yields per acre than the same kinds of grain grown separately in nearly the whole of the tests. Of the different mixtures used, the oats and barley gave the heaviest average yield of threshed grain per acre.

Oats and Barley Mixed and Sown in Different Proportions. It was decided in the spring of 1899 to conduct an experiment in sowing nine different proportions of oats and barley in order to determine which mixture and which quantity of seed would give the best results in the production of grain and straw. The experiment has therefore been conducted for six years in succession. The following table gives the quantities of oats and barley sown together, and the average yield of grain per acre in the average of six years' experiments :

| Oats. | Barley. | Yield per acre. |
|---|---|---|
| | | Pounds. |
| ½ bushel .. .. .. .. .. .. .. | ½ bushel .. .. .. .. .. .. .. | 2,240 |
| ½ bushel .. .. .. .. .. .. .. | 1 bushel .. .. .. .. .. .. .. | 2,163 |
| ½ bushel .. .. .. .. .. .. .. | 1½ bushel .. .. .. .. .. .. .. | 2,214 |
| 1 bushel .. .. .. .. .. .. .. | ½ bushel .. .. .. .. .. .. .. | 2,266 |
| 1 bushel .. .. .. .. .. .. .. | 1 bushel .. .. .. .. .. .. .. | 2,290 |
| 1 bushel .. .. .. .. .. .. .. | 1½ bushel .. .. .. .. .. .. .. | 2,281 |
| 1½ bushel .. .. .. .. .. .. .. | ½ bushel .. .. .. .. .. .. .. | 2,216 |
| 1½ bushel .. .. .. .. .. .. .. | 1 bushel .. .. .. .. .. .. .. | 2,241 |
| 1½ bushel .. .. .. .. .. .. .. | 1½ bushel .. .. .. .. .. .. .. | 2,177 |

We see by the foregoing figure that the greatest number of pounds of grain per acre was produced from a mixture of one bushel of oats (34 lbs.) and one bushel of barley (48 lbs.) per acre, or by a total amount of 82 pounds of the mixed seed per acre.

A Mixture of Oats and Barley With and Without Some Other Grain for Seed Purposes. In 1902, in 1903, and again in 1904, an experiment was conducted in duplicate in order to ascertain whether the seed mixture of one bushel of oats and one and a half bushels of barley per acre could be improved by the addition of a small quantity of some other kind of seed. In addition to the standard mixture of oats and barley, one-half bushel of grain was used in each mixture. The following yields per acre show the average results of the two tests for each of the three years as follows :

| | lbs. |
|---|---|
| Standard Mixture .................................................. | 2,509 |
| " " and 30 lbs. Wild Goose Spring Wheat ........... | 2,480 |
| " " " 22 pounds of Emmer.......................... | 2,500 |
| " " " 28 " Flax .......................... | 2,511 |
| " " " 30 " Black Hulless Barley............ | 2,469 |

The average results of this experiment for three years seem to indicate that it is very difficult to surpass the standard mixture of barley and oats in yield per acre by adding small quantities of other kinds of seed. If only one bushel of barley had been used instead of one and a half bushels for the standard mixture, possibly the other seed might have exerted an influence slightly more marked than is seen in the results of this experiment. A mixture of oats, barley, and flax has given very good satisfaction.

Twelve Kinds of Grain Grown in Combination. In the spring of 1902, an experiment was started in growing twelve kinds of grain in different combinations. One of the principal objects of this experiment was to ascertain the relative value of different kinds of grain when grown in combination in comparison with the same grains when grown separately. The different grains used for this mixture were as follows: Mandscheuri barley, Black Hulless barley, Spring rye, Early Alaska oats, field peas, Joanette Black oats, White Hulless barley, Emmer, Grass peas, Wild Goose spring wheat, vetches, and flax. The mixtures were made up in two different ways—first, by using the same amount of seed of each variety which is usually sown when the grains are grown separately, and second, by using equal quantities of seed of all the varieties. Each of the mixtures here described was sown at the rate of 56, 84, 112, 140, and 168 pounds of seed per acre. Each part of the experiment was conducted in duplicate. It will therefore be seen that there were four tests made with these different mixtures in each of the four years, and that sixty plots have been used for the test during the years 1902, 1903, and 1904. The average results for the three years show that 112 pounds of the mixture of seed per acre produced a greater yield of grain than either of the two lighter or the two heavier seedings.

The crop produced by the mixture of twelve kinds of grain and sown at the rate of 112 pounds per acre was carefully analysed in order to ascertain the percentage of yield of each of the separate crops. Those varieties which had the largest average percentage of seed in the crops produced were as follows: Mandscheuri barley, Black Hulless barley, Spring rye, Joanette Black oats, and Early Alaska oats. These five varieties furnished about two-thirds of the entire crop; while the other third was produced by the White Hulless barley, field peas, Grass peas, Emmer, Wild Goose spring wheat, Common Spring vetches, and flax. The Mandscheuri barley had the largest and the flax the smallest percentage in the crop produced from the mixture of the twelve varieties. This experiment goes to confirm other experiments, and to show that it is very difficult to make a mixture which will produce a heavier yield of grain per acre than one made of barley and oats.

Varieties of Oats and Barley for Growing in Combination. If oats and barley are grown in combination, it is, of course, important to secure those varieties which will mature at about the same time. In order to do this, it is necessary to use a very early variety of oats with an ordinary ripening barley, or a very late variety of barley to use with an oat which matures at an average date. Of all the varieties which we have used in combination, we have found that the Early Daubeney oats and the Mandscheuri barley make a very excellent combination. Another mixture which has given good satisfaction is the Siberian or Banner oats and the Chevalier two-rowed barley. It is, however, difficult to secure true seed of the Chevalier barley in Ontario at the present time. Taking everything into consideration, the first mixture here mentioned is one of the most satisfactory to use at the present time.

## Mangels.

The number of acres used for the mangel crop in Ontario has been greatly increased within the past twelve years. According to the report of the Bureau of Industries, we learn that from 1882 to 1902 an annual average area of 31,993 acres was used for the growing of mangels. In 1893 there were only 21,519, in 1894. 27,670, and in 1895, 34,383 acres. From that time forward there has been a gradual increase in the acreage of mangels up to 1903, when no less than 80,918 acres were used for this important crop in Ontario. In 1904, however, the acreage dropped to 71,344 acres, owing, no doubt, to the unfavorable weather at that time in the spring when the farmers were ready to sow their mangel crop. The average yield of mangels per acre for Ontario for the past twenty-three years has been 459 bushels, or about 13.8 tons.

VARIETIES. Twenty-three varieties of mangels have been carefully tested in our experimental grounds for five years in succession. The seeding has usually taken place near the first of May. There have been three rows of each variety, each row being four rods in length. Three and a third links (26 2-5 inches) were allowed between the rows, and ten inches between the mangels in the rows. The same distance was allowed between the different varieties as between the rows of the same variety. Level cultivation was practised throughout. The average results for the five years in yield of tops and in yield of roots per acre as follows :

| Varieties. | Average results for five years. | |
|---|---|---|
| | Yield of tops per acre. | Yield of roots per acre. |
| | Tons. | Tons. |
| 1. Yellow Leviathan .... .... .... ...... | 5.44 | 34.16 |
| 2. Mammoth Golden Giant .... .... .... | 5.90 | 33.79 |
| 3. Sutton's Mammoth Long Red ........ | 5.82 | 33.36 |
| 4. Oblong Giant Yellow or Giant Yellow Inter .... .... .... .... .... .... | 5.26 | 33.28 |
| 5. Steele, Briggs Giant Yellow Inter.... | 5.66 | 33.12 |
| 6. Carter's Mammoth Prize Long Red .... | 6.15 | 32.66 |
| 7. Evans' Improved Mammoth Sawlog.. | 6.53 | 32.40 |
| 8. Norbitan Giant .... .... .... ........ | 6.02 | 31.82 |
| 9. Simmers' Improved Mammoth Long Red .... .... .... .... .... ........ | 6.62 | 31.77 |
| 10. Steele's Long Red Selected ...... .... | 6.06 | 31.13 |
| 11. Cornish Giant Yellow Globe .... .... | 2.30 | 31.06 |
| 12. English Prize .... .... .... .... ...... | 6.52 | 30.64 |
| 13. Giant Yellow Half Long .... .... .... | 5.03 | 30.61 |
| 14. Long White .... .... .... .... ........ | 5.79 | 30.07 |
| 15. Buckbee's Mastadon .... .... .... .... | 6.79 | 30.07 |
| 16. Rennie's Perfection Mammoth Long Red .... .... .... .... .... ...... | 5.85 | 29.83 |
| 17. Carter's Windsor Prize Taker Yellow Globe .... .... .... .... .... .... | 2.24 | 29.60 |
| 18. Daniels' Improved Gate Post .... .... | 3.32 | 29.39 |
| 19. Carter's Elephant Yellow Globe ...... | 2.61 | 28.91 |
| 20. Taber's Gate Post Yellow Inter ...... | 3.45 | 28.78 |
| 21. Rivershall Giant Yellow Globe ...... | 2.57 | 28.24 |
| 22. Red Globe .... .... .... .... ........ | 4.30 | 27.95 |
| 23. Mammoth Red Intermediate .... .... | 3.39 | 26.11 |

The Yellow Leviathan, which stands at the head of the list in yield of roots per acre, is a yellow intermediate variety which has given very excellent satisfaction. In connection with the co-operative experimental work throughout Ontario in 1904, the Yellow Leviathan also gave the greatest yield of roots per acre, and, of the three varieties distributed, it was the most popular among the experimenters. The seed of this variety was obtained from D. M. Ferry, Windsor, Ontario. Within the past fifteen years, we have grown upwards of twenty-five different strains of the long red mangel, all of which have been surpassed by Yellow Leviathan intermediate variety.

In 1904, thirty-two varieties of mangels were under test. Among the newer kinds, the following produced the greatest yield per acre: Griewener, 29.9 tons; Giant Eckendorf, 28.1 tons; and Rennie's Golden Giant, 24.6 tons.

Soaking Seed Before Planting. For three years, an experiment has been conducted in which mangel seed has been soaked twelve, twenty-four, and thirty-six hours before sowing in comparison with mangel seed which was sown without being soaked. The average results of the three years' tests show that the mangel seed which was soaked twelve hours gave the highest yield of roots per acre, the average being 22.9 tons, as compared with 20.1 tons produced from the unsoaked seed. It is quite probable that the condition of the land at the time of sowing has much to do with the comparative results from soaked and unsoaked seed.

## Sugar Beets.

The total area devoted to the growing of sugar beets in Ontario is still quite limited. A considerable amount of interest, however, has been taken in this crop during the past few years, both for feeding purposes and for the manufacture of sugar. Usually those varieties which give a large yield per acre, are easily harvested, and contain an average of about ten per cent. of sugar, are the ones used for feeding purposes; and those varieties which grow mostly underground and furnish about 15 per cent. of sugar are the ones sown for sugar production.

Varieties. In our experimental work, we have made a comparative test of thirty-two varieties of sugar beets within the past five years. These include some of the leading varieties as grown for feeding purposes, and also some of the leading kinds which have been specially bred in Germany for many years for the production of sugar. In 1900 and in 1901, the sugar beet seed was planted in rows 26 inches apart, and the plants were thinned to a distance of 7.9 inches apart in the rows. In 1902, 1903, and again in 1904, however, all the varieties were planted in rows 21 inches apart, and a distance of seven inches was left between the plants. The thinning took place when the plants were quite small. Level cultivation was practised throughout. The following table gives the average yield per acre of duplicate experiments conducted with nineteen varieties in 1900, twenty-one varieties in 1901, thirty varieties in 1902, and thirty-two varieties in 1903 and again in 1904, as well as the average for the number of years that each variety was grown.

| Varieties. | Yield of roots per acre. | | | | | |
|---|---|---|---|---|---|---|
| | 1900. Tons. | 1901. Tons. | 1902. Tons. | 1903. Tons. | 1904. Tons. | Average Tons. |
| 1. Giant White Feeding | 14.05 | 17.22 | 25.38 | 31.53 | 38 44 | **25.32** |
| 2. Royal Giant | 14.95 | 19.29 | 29.63 | 26.55 | 33.14 | **24.71** |
| 3. New Danish Improved | 19.10 | 18.60 | 27.88 | 27.44 | 29.08 | **24.42** |
| 4. Red Top | 24.25 | 19.63 | 26.81 | 20.83 | 30.38 | **24.38** |
| 5. Giant Rose Feeding | 14.50 | 17.67 | 25.38 | 31.11 | 32.84 | **24.30** |
| 6. Red Skinned | 21.55 | 20.60 | 22.38 | 22.36 | 28.39 | **23.06** |
| 7. White French | 17.35 | 14.39 | 29.06 | 26.08 | 26.63 | **22.70** |
| 8. Green Top White | 18.35 | 18.91 | 26.56 | 20.47 | 25.73 | **22.00** |
| 9. White Silesian | 21.45 | 18.15 | 25.94 | 21.23 | 22.28 | **21.81** |
| 10. Lane's Improved | 20.45 | 16.28 | 22.75 | 22.08 | 24.30 | **21.17** |
| 11. Carter's Nursery | 13.35 | 14.93 | 29.38 | 27.02 | 20.78 | **21.09** |
| 12. Queen of the Danes | 11.65 | 12.63 | 20.00 | 29.27 | 25.91 | **21.09** |
| 13. Jersey | 13.70 | 14.63 | 20.69 | 23.06 | 30.31 | **20.48** |
| 14. Champion | 19.25 | 17.18 | 22.38 | 21.00 | 20.28 | **20.02** |
| 15. Kleinwanzlebener | 14.38 | 16.81 | 23.06 | 20.97 | 24.89 | **20.02** |
| 16. Pitzscheke's Elite | 14.85 | 14.61 | 20.63 | 30.70 | 21.20 | **18.40** |
| 17. Imperial Grey Top | 11.85 | 15.87 | 21.81 | 22.39 | 19.59 | **18.30** |
| 18. French Yellow | 13.15 | 15.14 | 23.19 | 19.48 | 19.25 | **18.04** |
| 19. Improved Imperial | 14.00 | 14.22 | 21.32 | 19.83 | 16.66 | **17.20** |
| 20. Mangel Sugar Beet | .......... | 13.01 | 20.50 | 21.27 | 19.08 | **18.47** |
| 21. Vilmorin's French Sugar | .......... | 13.22 | 19.44 | 21.45 | 16.38 | **17.62** |
| 22. Ideal | .......... | .......... | 30.13 | 31.69 | 32.16 | **31.32** |
| 23. Tankard Cream | .......... | .......... | 28.56 | 28.75 | 34.31 | **30.54** |
| 24. Rennie's Giant Sugar | .......... | .......... | 33.00 | 26.50 | 29.14 | **29.55** |
| 25. Rubensamen (Rimpau) | .......... | .......... | 21.06 | 19.67 | 21.02 | **20.58** |
| 26. Kleinwanzlebener (Mette) | .......... | .......... | 21.50 | 22.44 | 17.22 | **20.39** |
| 27. Jaensch's Victrix | .......... | .......... | 21.44 | 21.23 | 17.83 | **20.17** |
| 28. Dieckman No. 3 | .......... | .......... | 20.44 | 19.86 | 19.52 | **19.94** |
| 29. Dieckman No. 1 | .......... | .......... | 19.63 | 19.33 | 19.94 | **19.63** |
| 30. Dieckman No, 2 | .......... | .......... | 19.13 | 18.52 | 18.58 | **18.74** |
| 31. Hybrid Sugar Beet Mangel | .......... | .......... | .......... | 25.23 | 24.22 | **24.73** |
| 32. Imperial Giant Half Sugar | .......... | .......... | .......... | 25.02 | 21.06 | **23.04** |

In the average results for five years, the Giant White Feeding variety now occupies the highest place in yield of sugar beets per acre. The yield of this variety in 1904 was very large, being 38.4 tons per acre. The Royal Giant variety, which stood third in average yield of roots per acre in the average results for the last year, now occupies second place. The Kleinwanzlebener variety, which is so extensively used in the United States and Canada for sugar production, has given an average of 20 tons per acre for five years. This is considerably larger than is usually obtained in general practice, 15 tons being considered a satisfactory crop in general field cultivation. Among the newer varieties, the Ideal stands very high, giving an average of 31.3 tons per acre for three years. This is a special variety which has been bred up by Mr. A. Kirsche, of Germany, for stock feeding purposes. Several of the varieties near the end of the list, which have been grown for three years, were obtained from different sugar beet breeders in Germany who have made a specialty of selecting beets for years in order to obtain a high percentage of sugar. For the results of the chemical analyses of these beets, the reader is referred to the report of the Chemical Department, written by Prof. Harcourt, in the Report portion of this bulletin.

Some of the varieties of sugar beets have been grown at the College in uniform tests for eleven years in succession, the average results of the tests for the eleven years give us the following yields per acre for the different varieties: Red Top, 20.7 tons; Lane's Improved, 20 tons; White Silesian, 19.7 tons; White French, 19.1 tons; Champion, 18.9 tons; Red Skinned, 18 tons; Kleinwanzlebener, 17.5 tons; and Improved Imperial, 15 tons. In the average results for nine years, three other varieties have given the following average yields per acre: New Danish Improved, 22.6 tons; Jersey, 20.3 tons; and French Yellow, 18.1 tons.

Planting Sugar Beets at Different Distances Between the Drills. For three years in succession, an interesting experiment has been conducted in planting sugar beets at different distances in the rows. A comparison of nine different distances between the rows was made. Seven rows were sown at each distance apart. At the time of harvest, however, the two outside rows of each plot were discarded, and only the five inner rows were used in determining the comparative yields. The plants were thinned when very young, and were allowed to remain seven inches apart in the rows. Flat cultivation was used throughout. The experiment was conducted in duplicate, the Kleinwanzlebener variety being used in each of the tests. The average results of three years' tests in average weight per root, yield of tops per acre, and yield of roots per acre, are here presented:

| No. | Distanees. | Average of six tests. | | |
|---|---|---|---|---|
| | | Average weight per root, 1902-3-4. | Yield of tops per acre, 1902-3-4. | Yield of roots per acre, 1902-3-4. |
| | | Lbs. | Tons. | Tons. |
| 1 | Rows 12 inches apart | .71 | 11.37 | 23.02 |
| 2 | " 14 " | .74 | 8.92 | 21.43 |
| 3 | " 16 " | .80 | 9.22 | 20.66 |
| 4 | " 18 " | .87 | 9.39 | 20.25 |
| 5 | " 20 " | .96 | 9.28 | 20.23 |
| 6 | " 22 " | 1.01 | 9.47 | 19.74 |
| 7 | " 24 " | 1.07 | 8.96 | 19.38 |
| 8 | " 26 " | 1.14 | 8.92 | 19.09 |
| 9 | " 28 " | 1.20 | 8.69 | 17.83 |

It will be observed that the average results show regularity throughout. As the distance between the rows increased, there was a gradual increase in the comparative size of the individual roots, but a decrease in the yield of roots per acre. The roots which were placed in rows 18 inches apart, which is usually the distance recommended for the growing of beets for sugar production, produced an average of 20¼ tons of roots per acre. Some people think that larger yields can be obtained by having the rows of sugar beets 28 to 30 inches apart.

The average results of the six tests conducted within the past three years, however, have given us about 2 1-2 tons per acre more from the sugar beets grown in rows 18 inches apart as compared with those grown in rows 28 inches apart. Samples from the various parts of this experiment were taken to the chemical laboratory and were analyzed by Prof. Harcourt, in order to ascertain the percentage of sugar from beets grown in rows at different distances apart. For the results of these analyses, the reader is referred to the report of the Chemical department, to be found in the Report of the College for 1904.

Thinning Sugar Beets at Different Distances in the Drills. For two years in succession, an experiment has been conducted with sugar beets by thinning the plants to two, four, six, eight, and ten inches apart in the rows. Each plot consisted of six rows. fifty links (2 rods) in length, and eighteen inches apart. The experiment was conducted in duplicate in each of the two years, the Kleinwanzlebener variety being used throughout. The average results of the four tests made in the two years are as follows:

| Distance Between Plants. | Average weight per root. | Average yield of roots per acre. |
|---|---|---|
| | Pounds. | Tons. |
| 2 inches .... .... .... .... .... .... .......... | .52 | 19.7 |
| 4 inches .... .... .... .... .... .... .... .... | .87 | 16.7 |
| 6 inches .... .... .... .... .... .... .... .... | 1.02 | 16.2 |
| 8 inches .... .... .... .... .... .... .... .... | 1.21 | 15.1 |
| 10 inches .... ...... .. .... .... .... .... | 1.47 | 14.9 |

The results of this experiment seem to indicate that as the distance between the sugar beets in the rows increases, the average size of the individual roots also increases, but the yield of roots per acre decreases.

Flat and Ridged Cultivation. Sugar beets have been grown on the flat and on ridges in an experimental way in each of three years. The experiment in each year was conducted in duplicate. Each plot consisted of six rows, each row being fifty links (2 rods) in length. The Kleinwanzlebener variety was used throughout. The average results for the six tests conducted in the three years gave 18.82 tons per acre from the flat cultivation, and 18.17 tons per acre from the ridged cultivation. These results, therefore, show that for the three past years, about two-thirds of a ton more of sugar beets per acre have been obtained from the flat as compared with the ridged cultivation.

Thinning Plants at Different Stages. In each of the years 1903 and 1904, sugar beet plants were thinned when they were one-half inch, two inches, five inches, and eight inches in height. The experiment was conducted in duplicate each year, and the Kleinwanzlebener variety of sugar beets was used. The highest average yield per acre of the four tests conducted in the two years was obtained from the thinning which took place when the plants were two inches in height, the yield being fully one ton per acre more than for any of the other thinnings.

Soaking Sugar Beet Seed Before Planting. An experiment has been conducted for two years in succession by soaking sugar beet seed for twelve, twenty-four and thirty-six hours, and then sowing this seed as well as unsoaked seed in order to ascertain the comparative results of the different treatments. The experiment was conducted in duplicate each year. In each of the two years, the unsoaked seed gave the lowest yield of roots per acre. The results show us the greatest yield of roots per acre was obtained from the seed which was soaked for twelve hours in 1903, and from that which was soaked for twenty-four hours in 1904.

## Field Carrots.

In 1904, twenty-five varieties, and for each of the past five years, twenty varieties of field carrots have been grown in our experimental grounds. The carrot seed was sown on the level with a root drill in rows three and one-third links (26 2-5 inches) apart, and, when the plants were still quite small, they were thinned to an average distance of four inches apart in the rows. Three rows, each four rods in length, were used for each variety, thus making the plots exactly one one-hundredth of an acre in size. The average results for five years in weight per root, yield of tops per acre, and yield of roots per acre, are as follows:

| Varieties. | Average results for five years. | | |
|---|---|---|---|
| | Weight per root. | Yield of tops per acre. | Yield of roots per acre. |
| | Lbs. | Tons. | Tons. |
| 1. Mastadon White Intermediate | 1.04 | 6.68 | 31.16 |
| 2. Mammoth Intermediate Smooth White | 1.06 | 6.81 | 31.10 |
| 3. Steele's Improved Short White | 1.01 | 6.76 | 30.08 |
| 4. Iverson's Champion White Intermediate | 1.00 | 6.25 | 29.98 |
| 5. Sutton's Matchless White | .98 | 7.69 | 29.44 |
| 6. Carter's Hundred Ton | .96 | 6.06 | 29.17 |
| 7. Simmer's Short White Vosges | .96 | 6.56 | 28.03 |
| 8. Large White Belgian | .93 | 6.55 | 27.75 |
| 9. Long Yellow Stump Rooted | .87 | 5.32 | 26.57 |
| 10. Large White Vosges | .90 | 5.95 | 26.50 |
| 11. Pearce's Improved Half Long White | .87 | 7.72 | 25.90 |
| 12. Daniel's Giant Yellow Intermediate | .83 | 6.60 | 25.05 |
| 13. Sutton's Yellow Intermediate | .84 | 6.61 | 25.02 |
| 14. Carter's Gate Post Orange Long | .82 | 6.96 | 24.95 |
| 15. Rubicon Half Long Red | .83 | 5.45 | 24.83 |
| 16. Victoria Long Red | .81 | 6.58 | 24.04 |
| 17. Guerande | .78 | 4.86 | 23.55 |
| 18. Chantenay Short Red | .78 | 5.21 | 23.48 |
| 19. Danver's Orange | .79 | 5.90 | 21.73 |
| 20. Half Long Stump Rooted | .63 | 3.42 | 18.65 |

There are several varieties of intermediate white carrots, which are represented by different names and are obtained from different sources, which are quite similar in character of growth and in appearance, and which present results having variations that are not extreme. For instance, we observe from the table here presented that the Mastadon White Intermediate, the Mammoth Intermediate Smooth White, the Steele's Improved Short White, the Iverson's Champion White Intermediate, the Sutton's Matchless White, and the Carter's Hundred Ton, which are all intermediate white varieties, have a variation of about two tons per acre in the average results for five years. In comparison with this, however, we notice that the Half Long Stump Rooted gave a yield of only 18.7 tons of roots per acre.

Of the newer varieties, not included in the table here presented, the White Griewener, the American Beauty, the Carter's Orange Giant, and the Sutton's Magnum Bonum are among the most promising varieties.

## Swede Turnips.

Although the acreage sown to Swede turnips in Ontario at the present time is not much greater than the average for the past twenty-three years, we notice that there is yet nearly one-half as much more land devoted to the growing of this crop than to the cultivation of mangels and carrots combined. According to the report of the Bureau of Industries for Ontario, the average yield of turnips per acre for the past twenty-three years is 434 bushels, or about 13 tons per acre. The average yield of turnips throughout Ontario is 25 bushels, or three-quarters of a ton per acre less than that of mangels.

Varieties. Upwards of eighty varieties of Swede turnips have been under experiment at the College within the past fifteen years. Those varieties which produced the poorest results have been dropped from the list from time to time and only the leading varieties continued in the experiments. The following gives the names of leading varieties, with their average yield of roots per acre for the past five years: Sutton's Magnum Bonum, 23 tons; Buckbee's Giant, 21.9 tons; Kangaroo, 21.5 tons; Hall's Westbury, 20.9 tons; and Hartley's Bronze Top, 20.7 tons. In the co-operative experiments throughout Ontario, the Sutton's Magnum Bonum has given the highest yield of roots per acre in each of the years 1902, 1903, and 1904.

Selection of Seed. For five years in succession, experiments have been conducted with the object of securing information regarding the comparative value of different selections of turnip seed. Each year some of the best commercial seed of a leading variety of Swede turnips was purchased for this experiment. With the aid of sieves, the seed was carefully graded into large, medium, and small. The seed of each selection was then carefully hand-picked in order that nothing but apparently sound and perfect seed was used. The experiment was conducted in duplicate each year. The average results for the five years show the following yields of roots per acre: Large seed, 17.1 tons; medium-sized seed, 15.2 tons; and small seed, 8.7 tons.

## Fall Turnips.

Although fall turnips, soft turnips, or, as they are sometimes called, yellow and white flesh turnips, yield heavily per acre, they are not grown very extensively throughout Ontario, owing, no doubt, to the fact that they do not keep very late into the winter, but are more specially suited for feeding in the autumn of the year.

Varieties. Sixteen varieties were under test in 1904, and the results show that the highest yields per acre were produced by the Red Top White Globe, 44 tons; White Egg, 38 tons; Early American Red Top, 37 tons; Sutton's Imperial Green Globe, 37 tons; Sutton's Purple Top Mammoth, ~~ tons; Carter's Commonwealth, 35 tons; and Carter's Purple King, 35 tons.

In some seasons, this class of turnips is considerably damaged by what is commonly called the "turnip rot." This disease attacks the turnips during the growing season, and sometimes causes the root to become either partially or wholly decayed before they have been harvested. We have counted the number of sound roots, and also the number of decayed roots of each of the varieties grown in our experimental grounds for several years in succession. The crops grown in 1899, 1900, 1902, and 1903 were almost free from rot; while those grown in 1897 had 51 per cent; in 1898, 30 per cent; in 1901, 15 per cent; and in 1904, 2 per cent of rot. We submit herewith a table giving the names of the varieties and the percentage of the crop which was diseased in each of the years 1897, 1898, and 1901, with the average percentage of diseased roots for the three years.

| Varieties. | Per cent. of crop diseased. | | | |
|---|---|---|---|---|
| | 1897. | 1898. | 1901. | Average 3 years. |
| 1. Cow Horn | 2 | 7 | 5 | 5 |
| 2. Early American Purple Top | 8 | 6 | 1 | 5 |
| 3 Yellow Stone | 8 | 5 | 12 | 8 |
| 4. White Egg | 16 | 13 | 1 | 10 |
| 5. Jersey Navet | 28 | 2 | .. | 10 |
| 6. Red Top Strap Leaf | 29 | 7 | 5 | 14 |
| 7. Yellow Montgomery | 14 | 31 | 2 | 16 |
| 8. Jersey Lily | 27 | 4 | 20 | 17 |
| 9. Purple Top Mammoth | 23 | 26 | 5 | 18 |
| 10. Milk Globe | 26 | 27 | 7 | 20 |
| 11. Greystone Improved | 46 | 14 | 3 | 21 |
| 12. White Lily | 50 | 16 | 2 | 23 |
| 13. Green barrel | 37 | 24 | 10 | 24 |
| 14. White Six-weeks | 32 | 32 | 8 | 24 |
| 15 Red Top White Globe | 19 | 58 | 4 | 27 |
| 16. White Stone | 62 | 6 | 13 | 27 |
| 17. Sutton's Imperial Green Globe | 39 | 34 | 9 | 27 |
| 18. Early White Model | 35 | 21 | 27 | 28 |
| 19. Large White Norfolk | 42 | 35 | 7 | 28 |
| 20. Early La Crosse | 84 | 4 | 3 | 30 |
| 21. Purple Top Hybrid | 59 | 12 | 26 | 32 |
| 22. Red Globe Norfolk | 81 | 9 | 16 | 35 |
| 23. Jarman's Selected Green Globe | 47 | 53 | 11 | 37 |

| Varieties. | Per cent. of crop diseased. | | | |
|---|---|---|---|---|
| | 1897. | 1898. | 1901. | Average 3 years. |
| 24. Yellow Finland .... .... .... .... .... | 71 | 35 | 7 | 38 |
| 25. Long Tankard .... .... .... .... .... | 66 | 43 | 6 | 38 |
| 26. White Flat Dutch Strap Leaf ........ | 54 | 59 | 3 | 39 |
| 27. Imperial Green Glooe .... .... ...... | 43 | 27 | 48 | 39 |
| 28. Orange Sweet.. .... .... .... ........ | 77 | 36 | 11 | 41 |
| 29. Early Purple Top Munich .... ...... | 63 | 42 | 21 | 42 |
| 30. Sutton's Purple Top Scotch .... ...... | 78 | 42 | 7 | 42 |
| 31. Pomeranian White Globe .... ........ | 88 | 22 | 20 | 43 |
| 32. Orange Jelly .. ...... .. ...... ...... | 80 | 9 | 48 | 46 |
| 33. Sutton's Perfection Green Top ........ | 57 | 78 | 5 | 47 |
| 34. Sutton's Favorite Purple Top Yellow Hybrid .... .... .. .... .... .... | 65 | 61 | 15 | 47 |
| 35. Rennie's Selected White Globe ........ | 79 | 65 | 4 | 49 |
| 36. Yellow Aberdeen Green Top .......... | 77 | 21 | 52 | 50 |
| 37. Yellow Aberdeen Purple Top ........ | 83 | 19 | 64 | 55 |
| 38. All Gold .... .... .... .... ...... | 69 | 55 | 43 | 56 |
| 39. Extra Early Milan .... .... ........ | 75 | 70 | 23 | 56 |
| 40. Yellow Globe .... .... .... .... ...... | 83 | 65 | 31 | 60 |
| Average .... .... .... .... ...... | 51 | 30 | 15 | 32 |

Evidently the information given by Prof. F. C. Harrison on pages 27 and 28 of the College Bulletin 137, under the headino of "Susceptibility of Varieties," and on pages 16 and 17 of bulletin 136, under the headings of "Susceptibility of Varieties," and "The Planting of Immune Varieties," was based entirely on the notes taken by the Experimental Department in 1901. In bulletin 137, page 28, "Jersey Navet" should read "Jersey Navet"; "Warly La Crosse" should read "Early La Crosse"; "Lutton's Imperial Green Globe" should read "Sutton's Imperial Green Globe"; "Early Purple Top Murrich" should read "Early Purple Top Munich"; and in bulletin No. 136, page 17, "Red Top" should read "Red Top White Globe."

From the results here presented in tabulated form, it will be seen that none of the varieties were immune from the rot in the average of the three years' tests, but that three varieties, viz., the Cow Horn, the Early American Purple Top, and the Yellow Stone, had less than 10 per cent. of diseased roots. Those varieties having 10 and under 20 per cent. of decayed turnips were the White Egg, Jersey Navet, Red Top Strap Leaf, Yellow Montgomery, Jersey Lily, and Purple Top Mammoth.

In averaging the results for the five years during which the fall turinps were practically free from rot, we find the yield of each of five varieties to be as follows:

| Varieties. | Yield of tops per acre. | Average weight per root. | Yield of roots per acre. |
|---|---|---|---|
| | tons. | lbs. | tons. |
| Red Top White Globe | 4.2 | 2.28 | 26.5 |
| White Egg .... ...... .. | 5.2 | 2.00 | 23.0 |
| Early American Purple Top | 4.8 | 1.84 | 21.0 |
| Cow Horn .... ..... .. | 6.2 | 1.79 | 18.6 |
| Jersey Navet .... .... | 6.9 | 1.64 | 16.9 |

From these results, we learn that the Early American Purple Top and the White Egg varieties are not only among the freest from rot, but they are also heavy yielding varieties. The Jersey Navet turnip, which formerly gave very good yields, has given unsatisfactory returns during the past few seasons; so much so that we have dropped it from our lists entirely in our experiments with fall turnips in 1904.

SELECTION OF SEED. Large, medium, and small sized turnip seed has been sown on separate plots in each of four years. The experiment was conducted in duplicate each year, so that we now have average results of eight separate tests. The seed used on the different plots was of the same variety and of practically the same quality, except in size. The average yields produced from the different selections for the four years are as follows: Large seed, 25.4 tons; medium-sized seed, 21.7 tons; and small seed, 16.2 tons per acre.

### PARSNIPS.

Parsnips have not been grown very generally as a farm crop in Ontario. Enquiries have been received occasionally, however, asking about the yields of parsnips as compared with other classes of roots for cultivation as a stock food. Four varieties have now been grown for five years, the average yield of roots per acre being as follows: Buckbee's New Sugar, 11.5 tons; New Ideal Hollow Crown, 11 tons; Improved Half Long, 10.3 tons; and Improved Long Smooth, 10.1 tons. The Sutton's Cattle variety, which has been grown for four years in succession has given an average of 10.2 tons of roots per acre. It will be observed that the parsnips have yielded considerably less per acre than the leading varieties of mangels, sugar beets, turnips, or carrots.

### KOHL RABI.

This crop is sometimes grown for food for stock in some of the older countries. The root of the kohl rabi is somewhat like that of cabbage; while the leaves resemble those of Swede turnips. The valuable part of the plant, however, grows about three inches above the level of the ground in the form of a bulb. Kohl rabi makes a very nice food for domestic use, and is prepared for culinary purposes in much the same way as Swede turnips. The seed of kohl rabi resembles very closely that of Swede and fall turnips, and the crop is grown in much the same manner as turnips.

The following is the average yield in tons per acre of each of two varieties of kohl rabi grown in the experimental grounds for six years: Early White Vienna, 20.7 tons and Earliest Erfurt, 18.2 tons. The Goliath Purple variety, which has been grown for three years, gave an average of 16.7 tons per acre. In the crop of 1904, the yields were very high, being as follows: Early White Vienna, 27 1-2 tons; Earliest Erfurt, 26.9 tons; and Goliath Purple, 18.3 tons per acre. It will be seen from these results that the Early White Vienna gave the largest yield per acre in 1904, and also in the average of six years.

## Potatoes.

According to the reports of the Bureau of Industries, the potatoes grown in Ontario within the past twenty years have given a greater market value per acre than any other farm crop grown throughout the Province, being slightly in advance of that of field carrots, turnips, or m ngels, and about three times as great as wheat, oats, barley, or peas.

Varieties. One hundred and four varieties of potatoes were grown in the Experimental department in 1904, on what might be termed an average clay loam. Three rows each four rods in length and three and a third (26 2-5 inches) apart were used for each variety. Owing to the unfavorable weathe- during the latter part of May and the early part of June, the potatoes were not planted in 1904 until the tenth day of June. Furrows were made with a double mould board plow, and fifteen pounds of each variety were planted and covered to a depth of about four inches. Level cultivation was used throughout the season. B"- Death, which is clai to be an insecticide and also a fungicide, was sprayed on the tops of all the varieties on Jul- 13th, July 25th, and August 3rd. When the potatoes were dug in the autumn, careful determinations were made regarding the exact percentage of rotten potatoes, the yield of sound potatoes per acre, and the percentage of potatoes which were of the proper size to be marketable. As the rot both at the College and throughout Ontario was very bad in 1904 as well as in 1903, it is thought wise to present the results of all the varieties which were under experiment during both of these years. A table is therefore presented, giving the average number of days to reach maturity, the yield of sound potatoes per acre, and the percentage of rotten potatoes of each of the eighty-two varieties grown in 1903 1904.

| Varieties. | Average results ror two years, 1903-04. | | |
|---|---|---|---|
| | Number of days in reaching maturity. | Yield of sound potatoes per acre. | Percentage of potatoes rotten. |
| | | Bus. | |
| 1. Holborn's Abundance | 111 | 294.2 | 3.4 |
| 2. Robertson's Champion | 110 | 221.0 | 3.7 |
| 3. Skerries | 111 | 119.8 | 3.7 |
| 4. Up-to-date | 110 | 243.8 | 3.8 |
| 5. Stray Beauty | 87 | 196.5 | 4.8 |
| 6. Sensation | 109 | 187.2 | 5.1 |
| 7. Tremendous | 108 | 171.3 | 5.3 |
| 8. Factor | 110 | 206.1 | 5.3 |
| 9. Early Pinkeye | 84 | 259.0 | 5.4 |
| 10. Green Bay | 84 | 200.4 | 6.5 |
| 11. Seedling No. 230 | 93 | 290.1 | 7.0 |
| 12. Main Crop | 112 | 241.0 | 8.3 |
| 13. Bliss Triumph | 92 | 243.8 | 9 5 |
| 14. Gemmell's Seedling | 106 | 117.7 | 11.3 |
| 15. Salzer's Earliest | 90 | 279.8 | 12.1 |
| 16. Irish Cups | 103 | 267.5 | 13.9 |
| 17. Always | 97 | 204.2 | 14.6 |
| 18. Howe's Premium | 102 | 255.2 | 20.1 |
| 19. Carman No. 2 | 100 | 172.3 | 21.4 |

| Varieties. | Average results for two years, 1903-04. | | |
|---|---|---|---|
| | Number of days in reaching maturity. | Yield of sound potatoes per acre. | Percentage of potatoes rotten. |
| | | Bus. | |
| 20. Dewey | 101 | 200.4 | 21.9 |
| 21. Carter's Royalty | 101 | 106.7 | 23.4 |
| 22. White Giant | 98 | 134.4 | 25.0 |
| 23. Early Short Top | 93 | 106.0 | 26.1 |
| 24. Lightning Express | 91 | 200.4 | 26.5 |
| 25. Burbank's Seedling | 102 | 195.0 | 28.0 |
| 26. Sir Walter Raleigh | 99 | 165.6 | 28.2 |
| 27. Empire State | 105 | 232.5 | 28.9 |
| 28. Jersey Snowdrop | 98 | 147.1 | 29.1 |
| 29. Snowflake | 94 | 161.1 | 31.3 |
| 30. Early Michigan | 90 | 164.0 | 31.6 |
| 31. Rural Blush | 105 | 196.5 | 32.7 |
| 32. Carman No. 1 | 109 | 170.4 | 33.3 |
| 33. American Wonder | 103 | 218.1 | 34.4 |
| 34. Dempsey's Seedling | 102 | 218.5 | 34.9 |
| 35. Rural New Yorker No. 2 | 103 | 178.5 | 35.1 |
| 36. Uncle Sam | 101 | 148.1 | 35.5 |
| 37. North Pole | 95 | 156.7 | 35.6 |
| 38: Pearl of Savoy | 103 | 223.8 | 35.7 |
| 39. Celtic Beauty | 101 | 144.6 | 35.8 |
| 40. King of Michigan | 97 | 157.1 | 35.8 |
| 41. Steele's Earliest of All | 96 | 192.4 | 36.0 |
| 42. Canadian Beauty | 91 | 158.5 | 36.7 |
| 43. Early Dawn | 89 | 174.0 | 36.8 |
| 44. New White Beauty | 102 | 135.6 | 36.9 |
| 45. Adirondac | 107 | 165.6 | 37.4 |
| 46. Bovee | 93 | 163.1 | 37.6 |
| 47. Early Ohio | 89 | 158.1 | 38.1 |
| 47. Todd's White Monarch | 106 | 174.0 | 38.4 |
| 49. Sunlit Star | 102 | 165.0 | 39.3 |
| 50. Early Thoroughbred | 99 | 155.6 | 39.5 |
| 51. Early Rose | 102 | 138.8 | 39.9 |
| 52. Six Weeks | 90 | 145.6 | 40.3 |
| 53. Woodhull | 102 | 194.6 | 40.3 |
| 53. Early Fortune | 89 | 153.1 | 41.2 |
| 55. Early Andes | 89 | 165.4 | 41.6 |
| 56. Early Market | 93 | 156.7 | 41.7 |
| 57. Crown Jewel | 102 | 196.9 | 41.9 |
| 58. Burpee's Extra Early | 99 | 137.5 | 42.1 |
| 59. White Elephant | 102 | 198.9 | 42.8 |
| 60. Dublin Prize | 99 | 126.3 | 43.8 |
| 61. Rose of Quebec | 102 | 150.4 | 44.3 |
| 62. Dobson's Early | 96 | 102.9 | 44.5 |
| 63. Rose's New Invincible | 102 | 161.0 | 44.5 |
| 64. Democrat | 101 | 145.8 | 44.9 |
| 65. Burnaby Mammoth | 102 | 163.6 | 45.5 |
| 66. The Daisy | 100 | 167.1 | 46.0 |
| 67. Gem of the Hebrons | 102 | 164.4 | 47.5 |
| 68. Acme | 91 | 123.8 | 48.2 |
| 69. Leamington | 102 | 141.9 | 48.6 |
| 70. Rose of the North | 98 | 159.4 | 48.6 |
| 71. Wonder of the World | 98 | 136.3 | 49.9 |
| 72. Brown's Prolific | 102 | 145.2 | 50.3 |
| 73. Morning Star | 105 | 147.1 | 50.3 |
| 74. New Queen | 102 | 130.6 | 50.4 |
| 75. Lady Finger | 99 | 106.9 | 50.9 |
| 76. Surprise | 102 | 134.4 | 51.1 |
| 77. Hanlan Beauty | 102 | 129.6 | 52.8 |
| 78. Early Dominion | 95 | 122.7 | 53.3 |
| 79. White Pinkeye | 102 | 104.8 | 54.2 |
| 80. Beauty of Hebron | 102 | 153.3 | 56.2 |
| 81. Weld's Orange | 99 | 103.3 | 56.9 |
| 82. Montana Bluff | 105 | 144.2 | 58.3 |
| Average | 100 | 171.8 | 33.0 |

As the varieties presented in the table are arranged in the order of the percentage of rotten tubers, starting with the smallest and finishing with the greatest percentage of rot, the results regarding the percentage of disease are shown quite clearly. It will be seen that the Holborn Abundance, Robertson's Champion, Skerries, Up-to-date, and Stray Beauty varieties each had less than five per cent. of rot in comparison with the Beauty of Hebron, Weld's Orange, and Montana Bluff, each of which had upwards of fifty-five per cent. of rot.

It is claimed by some that early potatoes, and by others that late potatoes, are the freest from the attacks of this disease. According to the reports of the last two years, the average results of ten early, ten medium, and ten late varieties of potatoes are as follows:

| Classes According to Maturity. | Number of days in reaching maturity. | Percentage of rotten potatoes. |
|---|---|---|
| Ten early varieties .... .... .... .... .... | 88 | 25.8 |
| Ten medium varieties .... .... .... ...... | 100 | 33.8 |
| Ten late varieties .... .... .... .... .... | 110 | 10.9 |

From these results, it appears that of all the varieties grown in the Experimental Department in each of the past two years, the late varieties, as a whole, were the freest from rot.

Those varieties which had the largest percentage of rot did not yield as many sound potatoes as the varieties having the least percentage of rot, as will be seen by the following figures:

| Amount of Rot. | Bushels of sound potatoes per acre. | Percentage of rotten potatoes. |
|---|---|---|
| Twelve varieties having the least rot.... | 219.2 | 5.2 |
| Twelve varieties having the most rot .... | 129.9 | 52.9 |

This gives us some idea of the great loss caused by means of the rot on the potato crop of the past two years. The November Crop Bulletin for 1904 had the following regarding the condition of the potato crop: "The extent of the loss from rot is variously estimated at from twenty to fifty per cent." This will show the importance of planting those varieties which produce large yields of potatoes of good quality and which are less subject to rot than other varieties.

In averaging the yields per acre produced by each of forty-six varieties of potatoes grown in the experimental grounds for the past five years in succession, the greatest number of bushels of sound potatoes were produced by the following: Empire State, 269; Seedling No. 230, 256; Dempsey's Seedling, 252; Pearl of Savoy, 251; White Elephant, 251; American Wonder, 247; Holborn Abundance, 247; The Daisy, 243; Rural New Yorker No. 2, 243; and Rural Blush, 240.

About twenty new varieties of potatoes were grown in the experimental plots in 1904 for the first time; some of them being grown in very limited quantities, as only a small amount of seed could be obtained. A few potatoes of each of a number of new varieties were sent out by Mr. Kyle, Ontario Special Farm Labor Agent, from the Old Country, and were transferred to the Experimental Department by Prof. C. C. James, Deputy Minister of Agriculture. The varieties were as follows: Davies' Foundling, Davies' King Loth, Davies' Warrior, Davies' Dunion, and Scottish Triumph. As these varieties were planted in such small quantities, no record can here be made regarding the yield per acre for 1904. Of the Davies' Warrior there were in all twenty hills, and no rotten potatoes were found in the crop. The Davies' Dunion had only thirteen hills, and there was only one rotten potato at the time that the crop was harvested. It is unsafe, however, to say, from these results, that the Davies' Warrior is immune from this disease, as similar areas of land on which a few of other varieties were grown also gave no rot in 1904, but when a larger area was taken into consideration a few rotten potatoes were found.

In order to obtain fuller information regarding the comparative yield of very early potatoes, six rows of each of nine varieties have been planted in the spring of each of the years 1902, 1903, and 1904. Two rows of each variety were dug at the end of nine weeks, two rows at the end of twelve weeks, and the two remaining rows at the end of fifteen weeks after the planting took place. In the average for three years, the greatest yields produced at nine weeks after planting were by the following varieties: Early Andes, Early Dominion, Six Weeks, Early Fortune, and Early Dawn. The Stray Beauty variety, which gave excellent results in a similar experiment conducted for several years previous to 1902, has produced low yields per acre during the last two or three years. This is true not only in the experiments at the College, but also in the co-operative experiments throughout Ontario. Evidently this variety has passed its best period of life and is now deteriorating.

Bordeaux Mixture for the Potato Blight. Until the last two years, the potatoes grown in the Experimental Department have been comparatively free from blight, although in some parts of the Province the rot has proven very troublesome in some seasons. In those sections where the blight has been serious, some farmers have had excellent results from the use of the Bordeaux mixture, along with Paris green, the first spraying being done when the plants were about six inches in height, and the second and third sprayings at intervals of ten to fifteen days. In some cases, five or six sprayings of Bordeaux mixture have been made in the same season. In 1903, and again in 1904, an experiment was conducted in our experimental plots by spraying two varieties of potatoes with Paris green and Bordeaux mixture; and also the same varieties of potatoes with Paris green alone. The potatoes for this experiment were planted in 1903 on June 10th, and the sprayings took place on July 11th, July 23rd, and August 6th; and those in 1904 were planted on June 11th, and the sprayings took place on July 16th, July 29th, and August 4th. The Bordeaux mixture was made in the same way and in the same proportions as described in the College Bulletin No. 122, copies of which may be obtained from the Department of Agriculture, Toronto, Ontario. The results show that there was less rot on the potatoes on which the Bordeaux mixture and the Paris green were used than on those on which the Paris green was applied alone. In the case of both varieties of potatoes on which the Bordeaux mixture was used, the tops kept greener to a later date than those which did not receive this treatment.

Different Methods of Treatment for the Potato Beetle. Owing to the severe ravages of the Potato Beetle in Ontario, an experiment has been conducted in duplicate in each of nine years by using different methods for destroying the insect. The experiment consisted in spraying the potatoes with Paris green and water, Paris green and plaster, and Potato Bug Finish. The test was conducted in duplicate each year. As a rule, three applications were made on each crop. For the sake of comparison, one plot was allowed to remain untreated.

In 1902, in 1903, and again in 1904, six lots of each of two varieties of potatoes were carefully selected and planted on separate plots. After the potatoes had made sufficient growth and the potato beetles (bugs) had made their appearance, five plots of each variety were treated in different ways to destroy the beetle, and one plot of each variety was left untreated as a basis of comparison. The five treatments made in each of the years were as follows: (1) Paris green and water, using one pound of Paris green and 96 gallons of water per acre; (2) Paris green and plaster, using one pound of Paris green and thirty-eight pounds of plaster per acre and applying the mixture to the potatoes in the dry condition; (3) Potato Bug Finish, which was applied dry at the rate of twenty pounds per acre; (4) Bug Death and water, using on an average thirty-two pounds of Bug Death and 96 gallons of water per acre; and (5) Bug Death used in the same proportion as No. 1, but in the dry condition. Three applications of each of the five treatments were made in both cases. In the autumn, the potatoes from each of the twelve plots were dug and weighed. The following are the average results of the smaller experiment conducted for nine years, and of the larger experiment conducted for three years:

| Treatments. | Average number of bushels of potatoes per acre. | |
|---|---|---|
| | 9 years. | 3 years. |
| Nothing | 81.8 | 93.6 |
| Potato Bug Finish | 123.2 | 128.0 |
| Paris green and plaster | 132.3 | 146.9 |
| Paris green and water | 140.4 | 151.5 |
| Bug Death (dry) | ...... | 175.3 |
| Bug Death and water | ...... | 175.5 |

In seven out of the nine years, those potatoes which were sprayed with Paris green and water surpassed those which were sprayed with Paris green and plaster, in yield of crop per acre. It is also quite noticeable that in each of the nine years the untreated potatoes gave decidedly the lowest yield of tubers per acre. The Bug Death, which has only been tested in our trial grounds for the past three years, is manufactured at St. Stephen, N.B., and has been used to a limited extent throughout Ontario during the last two or three years. The potato tops on which Bug Death was applied were more vigorous in growth and greener in appearance throughout each of the seasons than those on which the other applications were made. In this respect, the Bug Death exerted an influence about equal to a combination of Paris green and Bordeaux mixture in each of the past two years. The usual prices of these insecticides, when bought in quantity, are about as follows: Paris green, 20 cents; Bug Death, 7 cents; and Potato Bug Finish, 1 2-3 cents per pound. The cost, therefore, for the material used in the experiments conducted in 1902, 1903, and 1904, was about as follows: Paris green and water, 60 cents; Paris green and plaster, 88 1-2 cents; Bug Death, $6.72; and Potato Bug Finish, $1.00 per acre.

Treatment of Potatoes to Destroy the Scab. An experiment was again conducted in 1904 by immersing scabby potatoes in a solution of corrosive sublimate for one and a half hours, after which they were spread out to dry; they were then cut and planted in the usual way. The treatment was made with each of two varieties. Both the treated and untreated potatoes were planted at the same time and in the usual manner. The corrosive sublimate solution was made by dissolving corrosive sublimate in hot water in the proportion of 2¼ ozs. of the former and two gallons of the latter. The solution was allowed to stand twelve hours, after which it was diluted with 13 gallons of water. As the corrosive sublimate is very poisonous, the material itself should be looked after very carefully and no potatoes which have been treated should be left unplanted. As none of the potatoes had more than one-half of one per cent. of scab in the crop of 1904, the results of this experiment do not furnish much information for this season. Taking the average of four years' results, the potatoes which were treated with corrosive sublimate gave about 7 bushels per acre more than those on which the corrosive sublimate was not used. This treatment has been used with good satisfaction in some places where there is usually a considerable amount of scabby potatoes.

Planting Different Sized Pieces at Different Distances Apart in the Rows. For three years in succession, an experiment has been conducted by planting one, one and a half, and two ounce pieces of potatoes. The potatoes of each of these sizes were planted twelve, eighteen, and twenty-four inches apart in the row. The average results show that the yield per acre increased in the order of the increase of the size of the pieces and of the decrease in the distance between the pieces in the row; thus, the highest average yield (177.6 bus.) was produced by the two ounce pieces planted one foot apart in the row, and the lowest yield per acre (107.3 bus.) was produced by the one ounce pieces planted two feet apart in the row.

Selection of Seed. For ten years in succession, large, medium-sized, small, and very small potatoes have been selected continuously and planted from season to season. The crop of 1904 shows, that as the seed decreased in size not only was there a decrease in the yield of potatoes per acre, but there was an increase in the percentage of small tubers.

Planting One, Two, and Four Potato Sets per Hill. For five years in succession, an experiment has been conducted by planting one, two, and four pieces of potatoes per hill, using the same amount of seed throughout. The average results for the five years are as follows: One two-ounce piece in a hill, 195.2 bushels; two one-ounce pieces in a hill, 182.9 bushels; and four one-half ounce pieces in a hill, 162.4 bushels per acre. The cutting of a potato tends to increase the number of stems produced, and when from two to four potato sets are planted in one place there is a greater number of stems produced than where one large piece in used. Evidently a few large, vigorous stems give better results than a large number of small, weakly stems, which are almost sure to grow where more than one piece is planted in each hill.

Methods of Planting Potatoes. Some farmers favor planting potatoes in rows 25 to 30 inches apart; while others favor planting in squares, or hills, from 30 to 40 inches apart both ways. An experiment has been conducted in our experimental grounds for seven years in succession, in order to compare the results of planting potatoes in rows three and a third links (26 2-5 inches) apart and having the potato sets one foot apart in the row in comparison with planting the potato sets in squares 33 inches apart both ways. The same amount of seed was used in each method, and the experiment was conducted in duplicate each year. The average results for seven years show, that the potatoes which were planted in rows gave 179.6 bushels, and those planted in squares gave 152.3 bushels per acre.

## Corn for Fodder and for the Silo.

There has not been much variation in the area devoted to fodder and silage corn in Ontario within the last few years. The average for the last two years, however, is about nineteen per cent. greater than for the past twenty-three years.

Varieties. It should be quite evident to a person familiar with the growth of fodder and silage corn throughout Ontario that no one variety is equally suited to all parts of the Province. It is also a fact that some of the varieties which give the best results in the middle

States of the American Union are entirely unsuited for cultivation in Ontario, owing to the shorter season of growth in Ontario as compared with that in some of the central States. Hence, the importance of testing a large number of varieties under similar conditions to ascertain not only the total yield of crop per acre but also the yield of ears or grain and the comparative earliness or lateness of the different varieties. In securing a suitable corn for the silo or for use as green or dry fodder, it is important to select a variety that produces a large total yield per acre and also gives a large yield of grain, and reaches a fair stage of maturity before the first nipping frosts occur in the locality where it is grown. Keeping these three points in view in experiments which have been conducted with a large number of varieties of corn for several years in succession, we have found that the Mammoth Cuban, Mastadon Dent, and Leaming are varieties which generally give good satisfaction on the warm soils of the southern part of Ontario, where large varieties of corn can be grown successfully; that the Wisconsin Earliest White Dent and the White Cap Yellow Dent give a good yield of total crop per acre which is of excellent quality, both of these varieties producing large yields of ears, and being specially suited to the central part of the Province where the frosts are not too severe; and that the King Phillip, Salzer's North Dakota, and Compton's Early varieties generally give good satisfaction in those parts of Ontario where the frosts are apt to occur at an early date. Of the one hundred and three varieties grown in the Experimental Department in 1904, the largest yields of ears per acre were produced by the following kinds: Early Windsor Sweet, 5.2 tons; Kendal's Early Giant Sweet, 5.2 tons; Ringleader Sweet, 5.0 tons; and Winconsin Beauty Sweet, 4.9 tons per acre. It will therefore be seen that the four varieties which have produced the greatest yields of ears per acre in 1904 were all sweet corns. These varieties are suitable for fodder purposes, but are not considered as valuable for silage as some of the Dent corns.

Methods of Cultivation. In 1902, 1903, and again in 1904, an experiment was conducted by cultivating corn in four different ways. The North Star Yellow Dent variety of corn was used in the experiment in 1902 and in 1903, and the White Cap Yellow Dent and King Phillip varieties in 1904. Each test consisted of four plots. The experiment was conducted in duplicate each year. The average results of the six tests conducted within the last three years are as follows: (1) Deep cultivation at first gradually getting shallower as the season advanced, 21.9 tons; (2) Shallow cultivation throughout the season, 21.2 tons; (3) Deep cultivation throughout the season, 20.8 tons; and (4) Shallow cultivation at first gradually getting deeper as the season advanced, 20.5 tons per acre. From these results, it will be seen that, in seasons such as we have had in the past three years, corn which was cultivated deeply immediately after it was planted and in which the cultivation was made shallower as the season advanced produced the greatest yield; while that which was cultivated shallow at first and deeper as the season passed by produced a lighter yield by fully one ton per acre.

### Sorghum for Fodder.

Eighteen varieties of sorghum were grown in the experimental grounds in 1904. These included different varieties of sugar cane, broom corn, kaffir corn, millo maize, etc. The greatest yields in the past season were produced by the following varieties: Orange Sugar Cane, 20.5 tons; Earliest Black Sugar Cane, 18.8 tons; Kenney's Improved Amber Sugar Cane, 18.1 tons; Folger Cane, 16.3 tons; and Early Minnesota Sugar Cane, 15.4 tons per acre. The greatest yields of heads in 1904 were produced by the Australian Broom Corn, 1.7 tons; California Golden Broom Corn, 1.6 tons; Dwarf Broom Corn, 1.6 tons; and Kenney's Improved Amber Sugar Cane, 1.5 tons per acre. In the average of eleven varieties grown for six years in succession, the highest yields of total crop per acre were produced by the Early Minnesota Sugar Cane, 16.6 tons; Orange Sugar Cane, 16.4 tons; Fodder Cane, 13.5 tons; Early Amber Sugar Cane, 13.3 tons; and Kaffir Corn, 11.2 tons per acre.

### Sunflowers for Fodder.

As considerable has been said regarding the practice of growing sunflowers and using the heads for cutting with corn for the silo, and as some farmers are growing sunflowers for this purpose, experiments have been conducted with several varieties within the past ten or twelve years in order to glean fuller information regarding the comparative value of the different varieties. Two varieties have now been under uniform tests for ten years in succession and have produced the following averages in tons of whole crop and of heads per acre: Black Giant, 19.8 and 5.8; and Mammoth Russian, 16.1 and 5.4, respectively. The White Beauty, which has been grown for seven years in succession, has produced an average of 16 tons of total crop and 5.8 tons of heads per acre. The results for 1904 were very high, showing a record for the Black Giant of 31.9 tons of total crop and 8.5 tons of heads per acre.

### Millet for Green Fodder and for Hay.

Twenty-five varieties of millet were grown in the Experimental Department in 1904, and determinations were made regarding the relative yields of green fodder and of hay. The results show us that the greatest yields of green crop were produced by the Japanese Panicle, 12.2 tons; East India Pearl, 10.7 tons; Early Harvest, 9.3 tons; Steel Trust, 9.2 tons; and Japanese Barnyard, 8.4 tons per acre. In comparison with these, the Hungarian Grass produced 8.2 tons of green crop. The Pencilaria produced 10.5 tons per acre, but no mention was made of this when giving the different varieties, as it is simply another name of the East India Pearl Millet. The greatest yields of hay in 1904 were produced by the Japanese Panicle, 4.5, and the Japanese Barnyard, 3.7 tons per acre.

As twelve of the varieties of millet have been grown for ten years in succession, the experiments cover a great variety of seasons. Those varieties producing large yields of green crop and of hay per acre are as follows: Golden Wonder, 11.2 tons of green crop and 4.5 tons of hay; Holy Terror Gold Mine, 10.8 tons of green crop and 4.5 tons of hay; Japanese Panicle, 10.1 tons of green crop and 4.5 tons of hay; Magic, 9.9 tons of green crop and 4.2 tons of hay; and Japanese Barnyard, 9.5 tons of green crop and 4 tons of hay per acre.

## Rape, Kale, Cabbage, Etc.

Although rape is known more or less throughout Ontario, neither cabbage or kale has been grown as a field crop on many of our farms for the purpose of furnishing food for farm stock. All these crops are grown more extensively in Great Britain than they are in Canada. Experiments have now been conducted in each of the past six years with fifteen varieties of rape, kale, cabbage, etc., in order to glean some information regarding the comparative yields of these varieties when grown under uniform conditions in Ontario. The seed has been sown in rows about 26 inches apart, and the land has been cultivated in much the same way as that containing a crop of turnips. Only about one pound of seed per acre is required when sown in rows and the land cultivated. The seeding has usually been done in June, and the crop harvested the latter part of September or in October. The following table gives the names of the varieties, the yield per acre in 1904, and the average yield per acre for six years of each of fifteen varieties:

| Varieties. | Yield per acre in 1904. | Average yield per acre for 6 years. |
|---|---|---|
| | Tons. | Tons. |
| Sutton's Earliest Drumhead Cabbage | 24.5 | 19.9 |
| Dwarf Essex Rape | 14.9 | 17.4 |
| Thousand Headed Kale | 19.0 | 17.1 |
| Dwarf Victoria Rape | 12.3 | 17.0 |
| Marrow Stem Kale | 21.0 | 16.8 |
| Purple Sprouting Boroccoli | 18.5 | 16.6 |
| Sutton's Earliest Sheepfold Cabbage | 25.0 | 16.2 |
| Marrow Collards | 22.7 | 15.7 |
| Hardy Curled Kale | 15.2 | 15.6 |
| Sutton's Best of All Savoy Cabbage | 18.3 | 14.9 |
| Jersey Kale | 15.4 | 14.8 |
| Sutton's Latest Drumhead Cabbage | 18.0 | 12.2 |
| Tall Green Curled Scotch Kale | 12.5 | 12.1 |
| Brussels Sprouts | 15.2 | 11.6 |
| Tall Jersey Cabbage | 2.9 | 7.8 |

It will be noticed that the two varieties of rape gave exceptionally low results in 1904. Among eighteen varieties of rape, kale, cabbage, etc., which have been grown for less than six years, the greatest yields in 1904 were as follows: Sutton's Giant Drumhead Cabbage, 24.4 tons; Large Seeded Common Rape, 20.8 tons; Large Seeded Umbrella Rape, 20.6 tons; Hammond's English Rape, 20 tons; Garton's Improved Thousand Headed Kale, 19.3 tons; and Buckbee's Wonderful Dwarf Bonanza Rape, 18.5 tons per acre. For a free donation of seed of several new varieties of rape, we are indebted to Mr. Dicks, of the Cooper-Taber Seed Growers, England.

## Green Fodder Crops.

Fifteen varieties of leguminous crops, including vetches, Soy beans, Cow peas, etc., have been grown in the experimental plots for four years in succession. As much interest has been taken in recent years in some of these crops, a table, giving the results of all the different crops which were grown under similar conditions, furnishes both interesting and valuable information.

| Varieties. | Average for 4 years. | |
|---|---|---|
| | Length of plants. | Yield of green crop per acre. |
| | Inches. | Tons. |
| Medium Green Soy Beans | 32.0 | 11.0 |
| Hairy Vetches | 33.5 | 10.2 |
| Common Vetches | ...... | 8.7 |
| Early Yellow Soy Beans | 27.0 | 8.5 |
| Grass Peas | 38.5 | 7.9 |
| Horse Beans | 31.0 | 6.7 |
| American Coffee Berry | 22.0 | 6.4 |
| Wonderful Cow Peas | 16.8 | 5.2 |
| Extra Early Blackeye Cow Peas | 16.8 | 5.0 |
| Taylor Cow Peas | 13.5 | 4.9 |
| Whip-poor-will Cow Peas | 14.3 | 4.4 |
| New Era Cow Peas | 13.5 | 4.4 |
| Warren's Extra Early Cow Peas | 13.0 | 3.7 |
| Extra Early Dwarf Soy Beans | 19.0 | 2.6 |
| Velvet Beans | 14.8 | 1.8 |

The Medium Green Soy beans, which stood first in the accompanying table in yield per acre, are an exceptionally fine variety, and, we believe, will be grown more and more for the production of fodder for feeding in the autumn or for mixing with corn when filling the silo, in order to increase the quality of the silage. If the Medium Green Soy beans are sown in rows 30 inches apart with the beans 8 inches apart in the row, at the time when the corn is planted, the crop will usually be ready for mixing with the corn for putting in the silo when the corn is in the best condition. The Hairy Vetches, as a rule, produce fully 4 tons per acre more than the Common Vetches, as shown by the results of these varieties which have been grown side by side for eight years in succession. The Grass peas have given very good results as a green crop in each of the past three years, but, owing to the peculiar conditions of the weather during the summers of 1902, 1903, and 1904, the Grass peas have not ripened as satisfactorily as they did in previous years. The varieties of Cow peas are not, as a rule, suitable for the production of either grain or fodder when grown in Ontario.

No less than twenty-seven different varieties of leguminous crops were tested under similar conditions in 1904. The greatest yields during the past season were obtained from the following varieties: Grass peas, 10.2 tons; Medium Green Soy beans, 9.5 tons; Ito San Soy beans, 8 tons; and Early Yellow Soy beans, 7.8 tons per acre.

### Winter Sowing of Winter Rye, Hairy Vetches, and Crimson Clover, for Fodder Production.

In the autumn of 1903, plots were sown with Winter Rye, Hairy Vetches, and Crimson Clover, with the object of ascertaining the comparative yields of green fodder produced from these crops in the following season. The Crimson Clover, however, was completely winter killed. Both the Winter Rye and the Hairy Vetches survived the winter in fairly good condition. Each crop was cut in 1904 when in its best condition as green fodder, the Winter Rye producing 15.2 and the Hairy Vetches, 12.1 tons of green crop per acre.

### The Wild Vetch as a Fodder Crop.

In the spring of 1902, Mr. F. W. Hodson, Live Stock Commissioner for Canada, forwarded some seed of the wild vetch, which is frequently observed growing in uncultivated land and especially along the railroads. The seed was sown in the spring of 1902, but the growth was exceedingly small in the following season. In 1903 the crop was also light, but in 1904 it took complete possession of the land, forming a network of roots and producing 7.6 tons of green crop per acre. It is quite probable that this would form a bad weed if used in regular rotations, but it might prove serviceable for sowing on rough land where grass and clover do not thrive and where a permanent crop is desired.

### Annual Crops for Pasture Purposes.

An experiment was conducted in 1900 and repeated in 1901, 1902, and in 1904, with the object of finding out which one of a number of annual crops would give the best results when used for pasture in the same year in which it is sown. For this experiment, fourteen varieties have been used. In each of the years, the crops were sown in three separate sets, there being fourteen plots in each set, thus making in all a total of forty-two plots each season. All the plots were sown each year on the same day and under similar conditions. The seed was sown in May in each of the four seasons. The three sets were handled in each year as follows:

Set 1. The crops on all the plots in Set 1 were cut at the end of six, nine, twelve, fifteen, and eighteen weeks after the seed was sown, thus making five cuttings for each crop. Each cutting was weighed in the green state, and also after it was dried in the form of hay.

Set 2. Each crop was cut when it was thought to contain the greatest bulk of best quality of green fodder. In order to ascertain the aftergrowth, another cutting was also made from each plot later in the season.

Set 3. A hurdle fence was placed around the set of eighteen plots, and cattle were turned on the plots daily until the pasture was all eaten. The first pasturing took place in the latter part of June and the early part of July. Careful notes were taken of the amount eaten of each crop each day. After the crops were pastured the first time, they were allowed to remain undisturbed until the autumn, when the cattle were again turned on, and the second growth was eaten off.

The average results for the four years, representing the yield of pasture for each of the five cuttings for the various crops under experiment, are here presented:

| Crops. | Tons of green pasture per acre at each of five cuttings per annum. Average of four years. | | | | | Total number of tons per acre per annum in five cuttings. |
|---|---|---|---|---|---|---|
| | 1st cutting. | 2nd cutting. | 3rd cutting. | 4th cutting. | 5th cutting. | |
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| 1. Hairy Vetches | 1.20 | 3.28 | 1.35 | 1.25 | .85 | **7.93** |
| 2. Common Red Clover | .06 | 1.91 | 2.09 | 1.69 | 1.61 | **7.36** |
| 3. Siberian Oats | 3.45 | 1.76 | 1.32 | .40 | .38 | **7.31** |
| 4. Crimson Clover | .05 | 2.64 | 1.76 | .97 | 1.79 | **7.21** |
| 5. Early Amber Sugar Cane | .14 | 2.04 | 2.63 | .97 | .91 | **6.69** |
| 6. Spring Rye | 5.07 | .55 | .35 | .09 | .09 | **6.15** |
| 7. Common Vetches | 1.73 | 1.97 | 1.10 | .63 | .62 | **6.05** |
| 8. Dwarf Essex Rape | .58 | 2.56 | 1.26 | .65 | .80 | **5.85** |
| 9. Mandscheuri Barley | 3.65 | .85 | .59 | .09 | .20 | **5.38** |
| 10. Hungarian Grass | 1.23 | 1.79 | 1.38 | .68 | .28 | **5.36** |
| 11. Compton's Early Corn | .95 | 2.46 | 1.04 | .35 | .01 | **4.81** |
| 12. Grass Peas | 1.68 | 2.06 | .83 | .17 | .03 | **4.77** |
| 13. Wild Goose Spring Wheat | 2.23 | 1.03 | .90 | .15 | .17 | **4.48** |
| 14. Soy Beans | .73 | 1.27 | .63 | .37 | .21 | **3.21** |

As the result of experiments previous to 1904, six different mixtures were formed and sown on different plots in the spring of the present year. The experiment was conducted in duplicate. The average yield of pasture produced from the five cuttings of each of the duplicate sets of the six mixtures are as follows: (1) Crimson Clover, Hairy Vetches, and Siberian Oats:—8.2 tons; (2) Hairy Vetches, Siberian Oats, and Early Amber Sugar Cane:—8.0 tons; (3) Siberian Oats, Early Amber Sugar Cane, and Common Red Clover:—8.0 tons; (4)

Common Red Clover, Emmer, and Hungarian Grass:—5.9 tons; (5) Early Amber Sugar Cane, Common Red Clover, and Emmer:—5.7 tons; and (6) Emmer, Hungarian Grass, and Spring Rye:—5.2 tons per acre. From a study of the results under this heading, it will be seen that a mixture of annual crops is likely to give a more satisfactory pasture during the same year it is sown than any of the crops when sown by themselves.

## Grasses and Clovers.

Of all the farm crops grown in Ontario, we believe there are none so important as the grasses and clovers used for hay and for pasture. Nearly six million acres of Ontario land are devoted annually to the production of hay and pasture; hence, the great importance of the farmers in this Province giving close attention to the different varieties of grasses and clovers for growing singly and in various combinations for the production of either hay or pasture.

Varieties of Grasses for the Production of Hay. Fifteen varieties of grasses, including some of our best native as well as some of the most noted European kinds, have been carefully tested in the Experimental department in each of seven different years. The grasses have usually been sown in the spring of the year with a light seeding of grain, as, for instance, one bushel of barley or a bushel and a peck of oats per acre. In the following and succeeding years, careful records have been made regarding the height of the different crops, the date at which they reached the proper condition to cut for hay, and the yield per acre of each cutting in each season. The following table gives the common and scientific names of the different varieties, the average date and height of the first cutting, and the total annual yield of hay per acre of each of fifteen varieties, these results being obtained from seven different years and from three separate seedings:

| Common name. | Scientific name. | Date of first cutting, average 3 years. | Height of first cutting, average 7 years. | Total annual yield of hay per acre, average 7 years. |
|---|---|---|---|---|
| | | | Inches. | Tons. |
| 1. Western Rye | Agropyron tenerum | July 12 | 31 | 4.36 |
| 2. Lyme Grass | Elymus virginicus | " 25 | 33 | 4.31 |
| 3. Fringed Brome | Bromus ciliatus | " 30 | 36 | 3.80 |
| 4. Timothy | Phleum pratense | " 7 | 35 | 3.47 |
| 5. Bearded Wheat | Agropyron caninum | " 26 | 35 | 3.27 |
| 6. Canadian Lyme | Elymus canadensis | " 27 | 32 | 3.25 |
| 7. Tall Oat | Arrhenatherum avenaceum | June 26 | 43 | 2.76 |
| 8. Orchard | Dactylis glomerata | " 27 | 34 | 2.55 |
| 9. Meadow Fescue | Festuca pratensis | July 1 | 32 | 2.23 |
| 10. Awnless Brome | Bromus inermis | " 7 | 26 | 2.18 |
| 11. Rhode Island Bent | Agrostis canina | " 13 | 25 | 1.97 |
| 12. Red Top | Agrostis vulgaris | " 9 | 23 | 1.79 |
| 13. Kentucky Blue | Poa pratensis | June 26 | 24 | 1.58 |
| 14. Meadow Foxtail | Alopecurus pratensis | " 22 | 31 | 1.55 |
| 15. Perennial Rye | Lolium perenne | " 29 | 20 | 1.25 |

The Western Rye, Lyme Grass, and Fringed Brome, which stand at the head of the list in yield of hay per acre, are all natives of Canada and have not yet been brought into field cultivation in Ontario. The Western Rye Grass which produced on an average nearly 4 1-2 tons of hay per acre is quite promising. Dr. Jas. Fletcher, Botanist at the Central Experimental Farm, Ottawa, in referring to the Western Rye Grass in his report for 1898, states that it has given most satisfactory results as a hay and pasture grass, and also states that Mr. S. A. Bedford, Superintendent of the Brandon Experimental Farm, who has grown the Western Rye Grass for many years, has always spoken of it in the highest terms. It is highly spoken of by Mr. Angus McKay of the Experimental Farm at Indian Head. In the report of the Dominion Experimental Farms for 1901, Dr. Fletcher states that "the Western Rye Grass, a native of the prairie regions, is a most valuable grass, and is now much cultivated for its rich and heavy crops of hay and seed." It will be seen from the table here presented that the varieties which are ready for cutting for hay production at the earliest dates are the Meadow Foxtail Grass, Tall Oat Grass, Kentucky Blue Grass, Orchard Grass, and Perennial Rye Grass, each of these varieties being usually cut in the latter part of June. The varieties here mentioned are from one to two weeks earlier than timothy; while the Lyme Grass, Fringed Brome Grass, Bearded Wheat, and Canadian Lyme are about three weeks later than timothy in reaching the proper stage for cutting as hay.

Varieties of Grasses for the Production of Pasture. It is indeed a difficult matter to make an exact comparison of a number of different kinds of grasses for pasture purposes. In experiments conducted for many years in England at Woburn in connection with the Royal Agricultural Society, as well as at other places, it is found unwise to attempt to compare different grass lands by having the crops pastured by sheep, unless at least three acres are used in each plot. If cattle were pastured on it, even larger plots than these would be necessary. It will therefore be seen that if a person wished to make a comparison of fifteen or twenty separate kinds of grasses for pasturing sheep or cattle, a very large amount of land would be necessary. It was thought, however, that some valuable information might be obtained by using smaller plots of land, and by cutting, weighing, and removing the crops from the land, instead of pasturing them with farm stock. An experiment has been conducted, therefore, for four years in succession, by cutting each of sixteen varieties of grasses at that time in the spring when the earliest varieties were ready for pasturing, and then cutting, weighing, and removing the crops produced by each of the varieties at each time during the summer when the more vigorous varieties had produced a sufficient growth for furnishing a good pasture crop. The following table gives the average of the four years' results of sixteen varieties of grasses at each of six different cuttings, as well as the total number of tons of pasture per acre per annum:

| Varieties. | Tons of green pasture per acre, at each of six cuttings per annum. Average of four years. | | | | | | Total number of tons per acre per annum in six cuttings. |
|---|---|---|---|---|---|---|---|
| | 1st cutting. | 2nd cutting. | 3rd cutting. | 4th cutting. | 5th cutting. | 6th cutting. | |
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| 1. Tall Oat | 5.93 | .83 | 1.59 | 1.23 | 1.33 | .87 | 11.8 |
| 2. Orchard | 4.34 | 1.71 | .92 | 1.30 | 1.05 | 1.40 | 10.7 |
| 3. Western Rye | 4.82 | 1.28 | .93 | 1.58 | .89 | .64 | 10.1 |
| 4. Canadian Lyme | 3.67 | 1.81 | 1.01 | 1.82 | 1.01 | .73 | 10.1 |
| 5. Bearded Wheat | 3.18 | 1.78 | 1.03 | 1.89 | 1.11 | .79 | 9.8 |
| 6. Meadow Fescue | 4.60 | 1.72 | .69 | 1.09 | .84 | .61 | 9.6 |
| 7. Virginia Lyme | 4.13 | 1.32 | .87 | 1.65 | .86 | .62 | 9.5 |
| 8. Tall Fescue | 4.70 | 1.75 | .78 | .87 | .74 | .59 | 9.4 |
| 9. Timothy | 4.87 | 1.71 | .58 | 1.11 | .62 | .49 | 9.4 |
| 10. Fringed Brome | 4.27 | .80 | 1.09 | 1.55 | .98 | .58 | 9.3 |
| 11. Awnless Brome | 4.53 | .96 | 1.04 | 1.26 | .63 | .62 | 9.0 |
| 12. Perennial Rye | 4.10 | 1.49 | .61 | .78 | .90 | .80 | 8.7 |
| 13. Meadow Foxtail | 3.81 | 1.32 | .72 | .95 | .53 | .37 | 7.7 |
| 14. Kentucky Blue | 3.76 | 1.04 | .73 | .78 | .58 | .58 | 7.5 |
| 15. Rhode Island Bent | 3.17 | 1.17 | .66 | .91 | .52 | .40 | 6.8 |
| 16. Red Top | 2.71 | 1.03 | .62 | .67 | .44 | .37 | 5.8 |

It will be seen that the Tall Oat Grass produced the greatest amount of pasture crop per acre, the average for the four years being nearly 12 tons per acre. It gave decidedly the largest yield at the first cutting, held out well in the middle of the summer, and furnished a fairly large amount of pasture crop in the autumn of the year. The Orchard Grass was especially strong in the autumn, producing the greatest quantity of pasture crop at the last cutting of the sixteen varieties of grasses under experiment. Although the Western Rye, Canadian Lyme, and Bearded Wheat have all given comparatively high results in yield of pasture crop per acre, a study of the experiment shows us that when these crops are cut six times during the season, the vitality of the plants becomes greatly exhausted and the crops are apt to be quite inferior in the following season. In the case of the Tall Oat, Orchard Grass, Meadow Fescue, and Tall Fescue, however, the vitality of the plants does not seem to be injured to any great extent by frequent cutting. The results of this experiment are very suggestive, and, we believe, furnish some valuable information regarding the special characteristics of different varieties of grasses when grown with the object of pasture. As a result of this experiment, we are obtaining valuable suggestions as to the most suitable combinations of grasses to use for permanent pastures.

Varieties of Clovers for the Production of Hay. A number of varieties of clover have been grown in the Experimental Department for the production of hay, but it has been difficult to get the results of a large number of varieties of clover under uniform conditions for a series of years. We are, however, presenting the average results of each of three varieties for a period of six years. The following table gives the average date of the first cutting for four years, the average height of the first cutting for six years, and the total annual yield of hay per acre for the average of six years.

| Varieties. | Date of first cutting, average 4 years. | Height of first cutting, average 6 years. | Total annual yield of Hay per acre, average 6 years. |
|---|---|---|---|
| | | Inches. | Tons. |
| Alsike | July 3 | 20 | **3.47** |
| Mammoth Red | " 11 | 25 | **3.31** |
| Common Red | June 27 | 22 | **2.95** |

It will be seen that in the average of four years' experiments the Common Red clover was ready to cut on the 27th of June, the Alsike clover on the 3rd of July, and the Mammoth Red clover on the 11th of July. According to this report, the first cutting of the Mammoth Red clover was exactly two weeks later than that of the Common Red variety. The Alsike clover, although producing the shortest plants in the first cutting, gave the largest average yield of hay per acre. It furnishes a close mat of growth. The Mammoth Red clover produces a large crop at the first cutting, but neither this variety nor the Alsike clover furnishes much of a second growth. In 1904 both the Alsike and the Mammoth Red varieties gave exceptionally high yields of hay per acre.

Varieties of Clover for the Production of Pasture An experiment has been conducted for three years by cutting each of eight varieties of clover and similar crops at five different times during the growing season, in order to ascertain the amount of pasture crop produced by each variety throughout the summer. The first cutting was made as soon as the earliest varieties had made sufficient growth to furnish a good pasture. Each of the other five cuttings were made at such times as the most vigorous growing varieties had produced sufficient growth for pasture purposes. As each cutting was made, the crop was weighed immediately in order to ascertain the exact yield of pasture crop produced by each variety. The following table gives the average results for three years of each of the six cuttings per annum of each variety:

| Varieties. | Tons of green pasture per acre, at each of six cuttings per annum. Average of three years. | | | | | | Total number of tons per acre per annum in six cuttings. |
|---|---|---|---|---|---|---|---|
| | 1st cutting. | 2nd cutting. | 3rd cutting. | 4th cutting. | 5th cutting. | 6th cutting. | |
| | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. | Tons. |
| 1. Lucerne | 8.73 | 3.06 | 2.70 | 3.62 | 1.56 | 1.27 | **20.9** |
| 2. Common Red | 10.88 | 1.10 | 2.37 | 3.39 | 1.52 | 1.15 | **20.4** |
| 3. Mammoth Red | 10.55 | 1.02 | 1.99 | 2.83 | 1.19 | 1.19 | **18.8** |
| 4. White or Dutch | 7.35 | 2.35 | 1.95 | 1.91 | 2.08 | 1.63 | **17.3** |
| 5. Alsike | 8.22 | .28 | 3.06 | 1.41 | 2.56 | .93 | **16.5** |
| 6. Yellow Trefoil | 5.07 | .19 | 2.59 | 2.18 | 2.10 | 1.02 | **13.2** |
| 7. Sainfoin | 4.64 | .67 | 1.78 | 2.73 | 1.19 | .79 | **11.8** |
| 8. Burnet | 2.64 | 1.39 | 1.05 | 1.52 | .59 | .41 | **7.6** |

According to the results here presented in tabulated form it will be seen that upwards of 20 tons per annum of green pasture crop per acre were produced by Lucerne and also by the Common Red clover. Each of these yields is about double that of Tall Oat grass and of Orchard grass previously reported. The White or Dutch clover made a high record, producing over 17 tons of green pasture crop per acre per annum. Although this clover does not produce a very large amount of hay, it will be seen that it furnishes a large amount of pasture, as it forms an exceedingly compact mass near the surface of the ground. The results which are here presented should be considered in connection with the results previously reported under the heading of "Varieties of Grasses for the Production of Pasture."

MIXTURES OF HARDY GRASSES AND CLOVERS FOR THE PRODUCTION OF EITHER HAY OR PASTURE. A large amount of experimental work has been done in testing varieties of grasses and clovers, both singly and in combination, within the past twenty-seven years. The grasses and clovers have been carefully studied, and much information has been gleaned in regard to their value, for hay and also for pasture. In 1885, Prof. Wm. Brown, who was then Farm Superintendent at the Ontario Agricultural College, recommended a mixture which he thought well adapted for permanent pasture. Only the most hardy varieties which had been tested up to that time were included in the mixture. In 1893, after eight years of additional experimental work, during which time the writer was closely connected with the work of the Experimental

| Grasses and Clovers. | Varieties in mixtures. | Amount of seed per acre. | Average height of 1st cutting for 10 years. | Yield of hay per acre. | |
|---|---|---|---|---|---|
| | | | | 1904, 2 cuttings. | Average for 10 years, 23 cuttings. |
| 1885. | | Lbs. | Inches. | Tons. | Tons. |
| Grasses ........ | Meadow Fescue .................. | 6 | | | |
| " ........ | Meadow Foxtail .................. | 3 | | | |
| " ........ | English Rye ..................... | 2 | | | |
| " ........ | Timothy ......................... | 3 | | | |
| " ........ | Canadian Blue ................... | 4 | | | |
| " ........ | Orchard ......................... | 3 | | | |
| " ........ | Red Top ......................... | 2 | 33.2 | 4.16 | 4.44 |
| " ........ | Yellow Oat ...................... | 2 | | | |
| Clovers ........ | Lucerne ......................... | 4 | | | |
| " ........ | White or Dutch .................. | 2 | | | |
| " ........ | Alsike .......................... | 2 | | | |
| " ........ | Red ............................. | 1 | | | |
| " ........ | Yellow or Trefoil ............... | 1 | | | |
| | | 35 | | | |
| 1893. | | | | | |
| Grasses ........ | Orchard ......................... | 4 | | | |
| " ........ | Meadow Fescue ................... | 4 | | | |
| " ........ | Tall Oat ........................ | 3 | | | |
| " ........ | Timothy ......................... | 2 | | | |
| " ........ | Meadow Foxtail .................. | 2 | 37.0 | 4.64 | 5.09 |
| Clovers ........ | Lucerne ......................... | 5 | | | |
| " ........ | Alsike .......................... | 2 | | | |
| " ........ | White or Dutch .................. | 1 | | | |
| " ........ | Yellow or Trefoil ............... | 1 | | | |
| | | 24 | | | |

Department, another mixture was recommended containing a smaller number of varieties and requiring a smaller amount of seed per acre. The grasses and clovers recommended in 1893 have proven themselves to be a valuable mixture. They are all hardy varieties, and when grown together give a large yield. An experiment was started in the spring of 1894 by sowing a plot of the mixture which was recommended in 1885, and a plot of the mixture which was recommended in 1893. The seed was sown with a light seeding of barley; and the germination of the seed of the grasses and clovers was quite satisfactory.

From two to three cuttings have been secured in each of the ten years from 1895 to 1904, inclusive. In 1904, which is the eleventh year since the plots were sown, two cuttings were taken from each plot. The total yield of hay produced from the two cuttings was 4.64 tons from the mixture recommended in 1893, and 4.16 tons from the mixture recommended in 1885. The figures represented in this report show the comparative yields of hay from the two mixtures; they also show that the grasses used for the mixtures are very suitable for an average soil in Ontario. These mixtures can be used for the production of either hay or pasture, but are more suitable for pasture purposes, owing to the unevenness in the maturity of the different varieties, which is a detriment to hay production but an advantage when the crop is used for pasture purposes. Without a single exception, the mixture which was recommended in 1893 has produced a larger yield per acre than that which was recommended in 1885. We have named all the varieties of grasses and clovers sown in each mixture, and also the quantity of seed per acre, in order to make the experiment as clear as possible, and also to furnish a guide for any person who wishes to know the quantity of seed per acre of the different varieties which are recommended as a permanent pasture mixture for an average Ontario soil. It will be observed that the mixture recommended in 1893 possessed none but very hardy grasses and clovers which have been tested at the College more or less for about twenty-six years. This mixture could, of course, be somewhat modified to suit different localities and different soils.

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ONTARIO AGRICULTURAL COLLEGE.

BULLETIN 141.

# Gas-Producing Bacteria

AND

# Their Effect on Milk and its Products.

By PROF. F. C. HARRISON,

Bacteriological Department

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ONTARIO AGRICULTURAL COLLEGE AND EXPERIMENTAL FARM

# GAS-PRODUCING BACTERIA AND THEIR EFFECT ON MILK AND ITS PRODUCTS.

By F. C. HARRISON, Professor of Bacteriology.

One of the commonest troubles in a cheese factory is the affection known to cheesemakers as "gassy" milk, which gives rise to off-flavors, and swelling and huffing of the cheese, and whilst it is impossible to give figures showing the financial loss by depreciation in the value of such tainted cheese, we know that such losses are frequently very serious.

Considering the importance of the bacteria which induce these changes in milk, very little attention has been given them by American bacteriologists, but in Europe, a number of valuable investigations have been made but under conditions which are very different from our own. On this account, a number of experiments were planned and carried out in the Bacteriological Laboratory of the College, aided by the facilities afforded by the College cheese factory.

Many of the details of these experiments are of a technical nature, dealing with the peculiarities of the shape, structure, and growth of the sixty-six varieties of gas-producing bacteria isolated from various sources. No mention will be made of these in this bulletin, but, in addition to the scientific data, a number of practical points were investigated which are now set forth in this bulletin.

The gas-producing bacteria were isolated from the milk supplied to the College Diary by farmers in the vicinity. This milk compared favorably with the ordinary factory supply, as constant endeavors have been made to instruct the patrons in the most approved manner of handling their milk. In spite of this fact, the College cheesemaker is very often bothered with gassy fermentations in the curd and cheese, and this investigation was undertaken in order to find out the habitat, ascertain the number and study the effects of the various species of gas-producing bacteria present in milk and cheese.

Samples of milk were taken in sterile tubes from the mixed milk of each farmer, and immediately brought to the laboratory and analysed. This sample,after taking out the quantity that was used for the analysis, was kept for a day or two at blood temperature in order to ascertain if gas was produced. Occasionally, we found gas bubbles in the milk sample, but no gas-producing bacteria developed in the gelatine plates, a probable proof of the small number of this class of organisms in the sample at the time the examination was made.

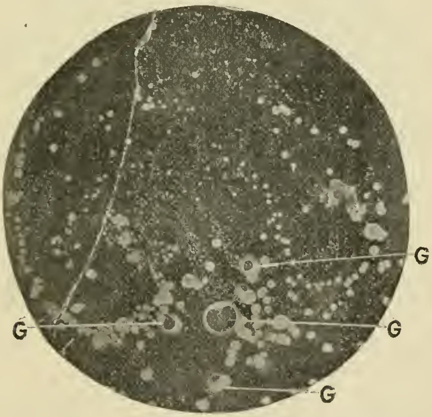
The samples of milk from some farms always showed gas, whilst from others it was only occasionally present, and a few samples never showed a trace. On the hottest days the number of gas-producing bacteria was often very large, whilst on cooler days the number present was always very small.

From a number of samples of milk obtained from other sources, we isolated gas-producing bacteria, but these samples were not so fresh as those we collected at the Dairy. The following table shows the results of the examination of milk from the College Dairy herd and from the mixed milk of farmers supplying the factory. A perusal of this table shows that for the 27 examinations here recorded the percentage of gas-producing bacteria varied from a fraction of one per cent. to over 34 per cent., with an average of 4.67. This table by no means represents the total number of examinations made, as in nearly every case each farmer's milk was examined from three to seven times.

| Source. | Total No. of Bacteria per cubic centimetre, (16 drops.) | No. of Gas-producing Bacteria per c c. (16 drops.) | Percentage. |
|---|---|---|---|
| Dairy Herd... ... ... ... ... ............ | 1,915,000 | 46,000 | 2.4 |
| Farmer H...... ... ......... ......... | 30,000,000 | 12,900 | 0.043 |
| " " ... ...... ... ...... ......... | 7,000,000 | 123,000 | 1.7 |
| " " ... ...... ... ...... ......... | 807,000 | 2,000 | 0.2 |
| Farm Department...... ... ... ... | 1,750,000 | 5,120 | 0.2 |
| " " ... ...... ... ... | 208,000 | 16,000 | 7.6 |
| Farmer G...... ... ... ... ... ... ...... | 40,600,000 | 96,000 | 0.2 |
| " Gn...... ...... ...... ......... | 539,000 | 154,300 | 28.6 |
| " H...... ............... | 49,000,000 | 112,000 | 0.2 |
| " " ... ...... ... ...... ......... | 714,000 | 3,840 | 0.5 |
| " D...... ......... ... ......... | 360,000 | 1,200 | 0.3 |
| " L...... ... ...... ... ...... ... | 3,240,000 | 77,500 | 2.3 |
| Dairy Herd... ... ... ... ... ........... | 7,737,000 | 6,240 | 0.08 |
| " " ... ......... ... ...... ... | 432,000 | 2,400 | 0.5 |
| " " ... ......... ... ...... ... | 3,000,000 | 333,600 | 11.1 |
| Farmer M...... ... ......... ...... | 17,000,000 | 153,000 | 0.9 |
| " " ... ...... ... ...... ......... | 29,000,000 | 3,200 | 0.011 |
| " " ... ...... ... ...... ......... | 101,000,000 | 43,000 | 0.04 |
| " McD... ... ... ............ | 3,494,000 | 112,000 | 3.2 |
| " " ... ...... ... ...... ......... | 9,885,000 | 3,397,000 | 34.2 |
| " H...... ...... ...... ......... | 77,000,000 | 448,000 | 0.53 |
| " P...... ...... ...... ......... | 4,170,000 | 794,440 | 19.0 |
| " " ...... ...... ...... ... ... | 270,000 | 9,000 | 3.3 |
| " " ...... ...... ...... ... ... | 446,000 | 2,880 | 0.6 |
| " R. L...... ...... ... ......... | 5,000,000 | 100,000 | 2.0 |
| " " ... ...... ... ...... ......... | 5,654,000 | 260,000 | 4.5 |
| " L...... ... ...... ... ...... ... | 1,872,000 | 36,000 | 1.92 |
| Average. | 14,892,333 | 235,208 | 4.67 |

Having ascertained the fact that numerous gas-producing bacteria were present in the milk as delivered at the factory, the next step was to try to find out how the gas-producing organisms got into the milk.

Some investigators have shown that the milk before it leaves the udder may be contaminated with bacteria, and further that these bacteria were occasionally gas-producing organisms. There is also a well known fact that inflammation of the udder (mastitis) is, at times, caused by gas-producing bacteria. Taking every possible precaution to guard against the entrance of germs from the air, and from the hairy coat of the animal, we examined the milk from the 25 cows comprising the Dairy herd, and from the milk of two of them a number of gas-producing bacteria were isolated. The results of this experiment are important, because it explains why some of the factory inspectors have been able to trace gas production to a single cow in a herd.




Photograph of gelatin plate, made from a drop of milk, shewing colonies of gas-producing germs. Each white dot is called a colony, and is made up of huge numbers of individual germs, the result of the continued growth of a single germ that was in the drop of milk, and which was held in place when the gelatin solidified. Note the gas bubbles at G.

Thirteen analyses were made of the stable air, but this was remarkably pure and no gas-producing bacteria were found.

During the movements of milking, particles of skin, hair, etc., and with them bacteria, are dislodged from the animal's coat, and drop into the milk pail. We found that gas-producing bacteria were present upon the hairy coat of the animal. When the udder and flanks were wiped with a wet cloth, these bacteria were prevented from falling into the pail, as germs are unable to leave a moist surface.

The cows drank from a wooden trough in the pasture field, and, on examination, this water was shown to contain gas-producing organisms which probably came from the soil, as the water obtained from the tap was remarkably pure, containing less than 20 bacteria per c.c. and none of these gas-producing forms.

By washing out clean, dry cans which had been cleaned in the ordinary manner with sterilized water, we obtained gas-producing bacteria.

Very many flies were present in the stable, and these frequently fell into the pail and added undesirable bacteria, which find in milk a good food for growth. A number of these flies were captured, and single flies were placed in test tubes containing a measured quantity of sterilized water and well shaken. This water on analysis was found to contain large numbers of gas-producing bacteria. Frequently, 50,000 bacteria were obtained from a single fly, and of these over 20,000 were gas-producing bacteria.

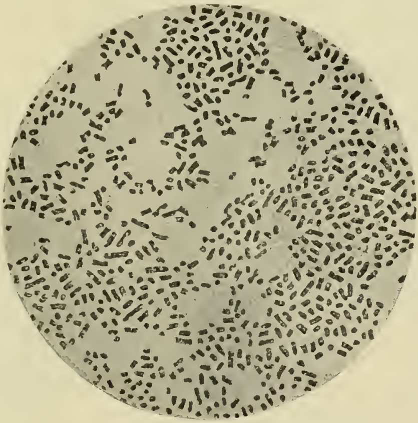
Large numbers of gas-producing bacteria were also obtained from manure. The ratio of gas-producing germs to other species in some 17 examinations was as 250 to 1. Cultures in sterilized milk made from some of these bacteria gave the peculiar odor known to cheesemakers as "gassy" milk, and others gave a characteristic "cowy" odor, although this peculiar smell has usually been ascribed to stable odors.

To summarize, gas-producing bacteria were found to be occasionally present (1) in the udders of certain cows, (2) on the hairy coat of the animal, (3) in clean, dry milk cans, (4) in the watering trough, (5) from flies, and (6) from manure. From these various locations, the gas-producing bacteria may contaminate the milk.

The gas-producing bacteria were readily killed by an exposure to temperatures ranging from 137 degrees to 146 degrees F. for 10 minutes. They were all killed by immersion in a 2 per cent. ammonia washing powder solution at 140 degrees F. and also in a 2 per cent. soda solution at 140 degrees F. for 10 minutes. These soda and ammonia washing powders are scarcely more effective than hot water for the destruction of these bacteria, but these substances aid in washing by helping to remove the dirt.

By continued growth in milk it was found that these gas-producing bacteria increased their power of fermenting the milk sugar. Thus, one variety, which originally produced 26 per cent. of gas, after growing for some time in milk produced 62 per cent.; hence those bacteria which were not killed by the hot water used in washing the cans would be more liable to produce larger quantities of gas than those which came in from other sources.

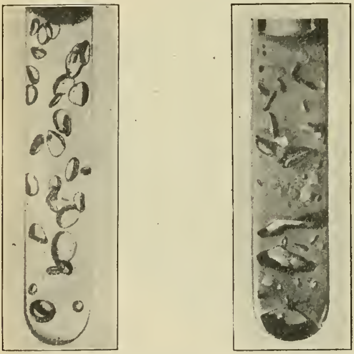
In dairy practice a starter or culture of a lactic acid bacillus is used to overcome the gassy fermentation of milk, and in order to quantitatively establish the working of this process, a number of experiments were instituted, in which gas-producing and lactic acid organisms were mixed together in order to study their antagonistic relations. The results of these experiments in general showed that the number of gas-producing germs decreased with the increase of lactic acid bacteria. Occasionally, however, some organisms were experimented with which were not so adversely influenced by the lactic acid germs.



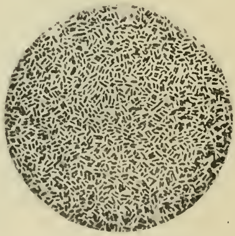
Gas-producing bacteria ; magnified 1500 diameters.

Cheese Experiments. A number of cheese were made from milk to which various quantities of a culture of gas-producing bacteria was added. A few of these experiments my be cited :—A cheese was made on the 5th of October from 300 pounds of milk to which 2 pounds of a 24 hour old milk culture of a gas-producing variety was added. This culture was acid, very gassy, with a bitter, astringent taste. The cheese curd was also very gassy, floating on the top of the whey. After making, the cheese was put into the curing-room with an average temperature of 55 degrees F., and bacteriological analyses were made from time to time. At the age of 21 days, the percentage of gas-producers was 76, at the end of 38 days, 71; and at the end of 52 days, 11; and at this stage, the cheese showed white and grey lines and spots, an appearance known amongst cheesemakers as "mottled." The cheese was scored, but no points could be given to it for flavor. The odor was something like rotten meat, and the mottled appearance was very striking.

A second cheese was made with a different culture of a gas-producing organism, and at the age of seven days was found to contain 15 per cent. of gas-producers. This number gradually declined, and at the age of 45 days only 2 per cent. of gas-producing bacteria were present. The cheese was examined at the end of 63 days, and was found to be slightly unpleasant in smell and taste, but was judged to be better than that made on the 5th of October, receiving 15 points out of 45 for flavor. On November 2nd, two cheeses were made. In the A cheese, $\frac{1}{2}$ per cent. of a 24 hour old milk culture of a gas-producing germ was used, and in the B cheese $\frac{1}{2}$ per cent. of the same culture and $\frac{1}{2}$ per cent. of the lactic acid bacillus. Both curds were floating about three hours from setting; the flavor was gassy. The B curd was better than the A, although even B was very



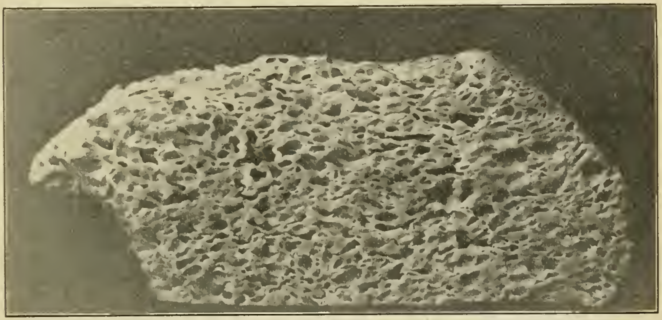
Growth of gas-producing germs in test tubes containing sugar gelatin. Note the gas bubbles.



Gas-producing bacteria; magnified 1000 diameters.

gassy. The B cheese was placed in an ordinary curing-room, and the percentage of gas-producing germs at the age of 10 days was .5. The cheese was examined at the end of 63 days, and was found to be slightly mottled, with fair flavor. The curd for the A cheese was divided into equal portions, one of which was placed in an ordinary curing-room at a temperature of 55 degrees to 60 degrees F., and the other put into the refrigerator curing-room, the average temperature of which was 40 degrees F. The percentage of gas-producing germs in both of these cheeses was very high. They were judged at the end of 63 days, when the taste and odor of both were found to be bad. The appearance of the one in the ordinary curing-room was very mottled. The one in the refrigerator curing-room was also mottled, but to a lesser extent.

These experiments show that gas-producing germs are able to produce a bad odor and flavor in cheese, and cause a mottled appearance, which is probably brought about by the bleaching action of the gases generated by the organisms introduced in the culture. The good effect of a lactic acid starter when these injurious bacteria were present was very noticeable, and caused great improvement in the flavor and appearance of the cheese.



A piece of curd taken from a vat ripened with a starter containing gas-producing bacteria.

A floating curd caused by gas-producing bacteria.

BUTTER EXPERIMENTS. Pasteurized cream was inoculated with 5 per cent. of a gas-producing culture, ripened for 24 hours at 58 degrees, and then churned. The butter had a bitter, disagreeable, and slightly astringent flavor, and scored only 32 per cent. These experiments were subsequently repeated with other varieties of gas-producing bacteria, and with the same results, showing that these organisms were just as injurious to the flavor of the butter as they were to the flavor of cheese.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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| 107 | May | 1898 | Dairy Bulletin (out of print, see No. 114) | Dairy School. |
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| 109 | Sept. | 1898 | Farmyard Manure | G. E. Day. |
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| 135 | June | 1904 | The Cream-Gathering Creamery | H. H. Dean.<br>J. A. McFeeters. |
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| 141 | April | 1905 | Gas-Producing Bacteria and Their Effect on Milk and its Products | F. C. Harrison. |

ONTARIO AGRICULTURAL COLLEGE.

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BULLETIN 142.

# Outlines of Nature Studies

By WILLIAM LOCHHEAD, B.A.,M.S.,
Professor of Biology and Geology.

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# OUTLINES OF NATURE STUDIES.

By William Lochhead, B.A., M.S., Professor of Biology and Geology.

## TO THE TEACHER.

This Bulletin is published for you (not for the children), with the hope that it may help you in your own studies of Nature. It is not intended that you deal with all of the studies outlined in the bulletin, as the subjects are purposely given a wide range to meet the needs and aptitudes of teachers as a professional body. The questions are for *you* to answer as you investigate each problem presented. When you are familiar with the problem you will, if you are a good teacher, frame other and better questions for your pupils.

Nature-Study from your view-point as a teacher is *Natural Study,* a *method* or means of developing mental power in the pupil under the careful guidance of the teacher, by encouraging close observation of the things of Nature which lie about him, and by begetting an attitude of inquiry into their meaning so that the truth is discovered through the exercise of the pupil's own self-activities.

It is quite true that there are other values in Nature-Study, but they are secondary, viewed from a pedagogical standpoint. With many persons the acquisition of information about the things of Nature by a study of Nature is the chief aim; while with others the development of a sympathy with, and an interest in the common things that surround them, is the only value in its sudy. These secondary values are very great, but they can be realized as a matter of course by making method the chief aim of Nature-Study. Now we have Sympathy, Information, and Method, but the greatest of these is Method.

It is your duty, as a teacher, to develop this method of study among your scholars. You should know the mental characteristics of every child in your school, if you are to get the best results. You should also have a fair knowledge of the subject which you are asking the children to investigate, else your probing, sustaining, question, and your direction of the children's work will soon cease. The great needs of the teacher at the present juncture are *knowledge of the subject-matter,* and a *correct meaning of the Nature-Study Method.*

## What Subject to Take up First ?

Whatever has an interest for the children, whatever has an interest for you, or whatever is suggested by a reading lesson. Once you *begin* you will be surprised at the number of subjects which come up for investigation,—but *be sure to begin.*

## How to Make the Study Effective ?

1. Whenever possible, make it the basis for (a) *oral expression* (extempore addresses); (b) *written expression* (reports and composition); (c) *form expression* (drawing and modeling); (d) *color expression* (painting).

2. As far as possible correlate it with the other school studies, which will frequently be vitalised and refreshed by the correlation.

3. Encourage the making of collections of natural objects, and have school exhibitions at intervals.

4. Have boxes and cages for such live animals as toad, snake, rabbit, or crow, and flower-boxes for plants near the window.

5. Encourage the children to keep a diary of things seen outside of school, such as first flowers, first birds, first frost, first snow-fall, etc., etc. A school diary should also be kept, in which the children may make entries. (Nature-Study Journal).

6. Keep a school-garden. Get help if necessary from a neighbor, but keep a garden. By its means many problems can here be worked out in a concrete form. Have a school exhibit at the close of the season.

7. Give practice in *sight seeing*, or in reporting *Voyages of Discovery.*

8. Finally, try and read some of the most excellent books on Nature-Study which have been recently published. Get some of the best every year for your school library.

The new prescribed course in Nature-Study for Public Schools is quite explicit as to the scope of the work to be done in each form, but it must be noted that much latitude is given the teacher as to the subjects and mode of treatment. This is as it should be, for Nature-Study cannot be taught by a machine. It stands for independence and the full expression of the personality of the teacher. It stands also for the active pupil and the suggesting teacher.

# OUTLINES OF NATURE STUDIES.

## THE TERRARIUM.

A terrarium is easily made from an old berry crate or soap-box; it should contain three inches of good rich soil and the open sides covered with netting. Sod with lawn grass will do admirably. Other plants, such as thistles, clover, cabbage, etc., should also find a place in it. There should be a mossy corner where shy creatures may hide. The terrarium is of great value in Nature-Study for in it can be kept many creatures, such as caterpillars, crickets, grasshoppers and locusts, toads, and salamanders, and many others. It is then possible to study their habits at close range. The secret of making full use of a terrarium is to imitate nature, and to make the conditions for the encaged creatures as natural as possible.

## THE AQUARIUM.

See O. A. C. Bulletin 134, "Hints on Making Nature Collections," page 7 on the making of an aquarium.

It requires a little experience and some experimenting to ascertain the right balance between the plants and animals of an aquarium. At the bottom there should be two or three inches of clean sand and a few stones. Only those animals and plants should be chosen which live in quiet water. When the balance is once established, but little attention is required beyond the addition of water. Every school should have an aquarium of some kind.

### I. Plant Societies.

1. What is a plant society? Why do plants grow in societies?

2. What factors (ecological factors) determine the vegetation types by influencing their life and growth? What is a vegetation type? a flora?

3. Distinguish societies and colonies.

4. How do plants associate? Find examples.

5. Explain how societies may differ at different times of the year.

6. Name some common plant societies, and determine the main factor influencing the type.

7. Explain clearly: layers, zone, tension line, mesophyte, xerophyte, hydrophyte, and halophyte.

8. Discuss "Plant Migration" and "Distribution," the lines of stress, lines of migration, the causes of migration, the structural characters favoring migration.

9. Explain why autumnal coloration is so striking in American forests.

10. Determine the adaptations of the members of the different societies to their environment.

11. Make special studies of the plants of one or more of the following: (a) a swamp, (b) a pasture or meadow, (c) a roadside, (d) a thicket, (e) a woods, (f) a lawn, (g) a cliff, (h) a barnyard, (i) a sphagnum swamp or bog, (j) a pond, (k) rocks, (l) sand-dune, (m) a ravine, (n) a shore, (o) a dry hill-side.

Make (a) list of the species of plants growing in each society; (b) determine the relative abundance of each species; (c) locate the positions of each species, (d) and try to explain any adaptations.

12. Make diagrams of distribution of the plants in each area studied.

13. Observe and try to explain the adaptation in the following: (a) strengthening devices in the large leaves of milkweeds, basswood, and catalpa, (b) flat prostrate habit of many shrubs, (c) elastic stems of cereals, (d) hairy leaves of mullein, (e) colored buds, (f) underground fleshy roots and tubers, (g) "sleep" position of clover leaves, (h) rosette habit of dandelion, blueweed, and plantain, (i) thickened leaves of purslane.

14. Study the swamp-thicket society near your school.

[Consult Coulter and Atkinson.]

## II. Flower Calendar.

Each student should keep a *Flower Calendar* for *Wild Flowers.*

| Date. | Name of Flower. | Kind of Soil. | Shade or Sheltered. | Remarks. |
|---|---|---|---|---|
| | | | | |

The flowers are not to be picked, but rather studied in their wild haunts.

By examination of the earlier plants determine how they have developed so rapidly.

What advantage to the plant in developing so early?

Examine the roots of some of the early plants.

Compare the first pair of leaves produced with the later ones.

## III. *Some Spring Flowers.*

SKUNK CABBAGE.

Note its habitat, and time of flowering, and answer the following questions:

1. Do leaves or flowers appear first ?
2. Make a drawing of the peculiar flower.
3. Do the stamens and pistils mature at the same time?
4. What insects visit the flower ?
5. What kind of roots has it, and why can it appear so early ?
6. What is the nature of the mature fruit?

JACK-IN-THE-PULPIT.

1. Compare Jack-in-the-Pulpit with Skunk Cabbage. Are these plants related ?
2. What insects visit Jack ? What is his habitat ?

HEPATICA.

Note:

1. Habitat.
2. Color—are all of same color?
3. Fragrance.
4. Insects that visit the flowers.
5. Texture and color of leaves of fall and spring leaves.
6. Buds in the fall.

TRILLIUM.

Note carefully:

1. The habitat or home of the Trillium.
2. The species and their differences.
3. The underground portion.
4. The color, fragrance, and insects.

## IV. *Some Autumn Flowers.*

BUTTER-AND-EGGS OR TOADFLAX.

Note where this plant grows and answer the following questions:

1. What insects visit the flowers ?
2. What attracts the insects ? Find where the attracting substance is kept. Is there any marking to guide the insect to the right place ?
3. Do the stamens and pistils mature at the same time ?
4. What is the nature of the root system, and why is this plant hard to eradicate? Describe and draw the flower and fruit. To what family does it belong ?

SUNFLOWER.

1. Make a daily record of the changes in position of the head with reference to the sun. Do old plants change as readily as young plants?

2. Is the plant affected by other conditions, such as cold, dew, rain, etc ?

3. Study the structure of the head, and locate the involucre, rays, and disk.

4. What difference between the ray and disk florets ? Draw one of each, and name the parts.

5. Do the stamens and pistils mature at the same time ?

6. What insects visit the flowers ?

7. Describe and draw the fruit.

8. To what family does the Sunflower belong? Name other members.

GARDEN NASTURTIUM.

Examine flowers in all stages of maturity, and answer the following questions :

1. Describe the position of the stamens before the pollen is ripe; when the pollen is ripe. Are all the stamens ripe at the same time ?

2. Describe the position and condition of the style with reference to the stamens at different degrees of ripeness.

3. What is the use of the spur ? Are there "guide lines" to the opening of the spur? What is their position?

4. Why does not the flower stand erect?

5. Make drawings of the flower.

[Consult Newell's Outlines of Botany.]

## V. The Dandelion.

1. Determine the arrangement of the LEAVES of the Dandelion; what is the purpose of this arrangement? Number and shape of the leaves? Do you see any special adaptations ? What about the leaves of Dandelions growing in long grass? Under boards?

2. Where is the STEM of the Dandelion ? Determine its length and thickness. Account for the circular markings and scars on the stem. What special advantages in such a short stem ?

3. Describe the ROOT of a Dandelion which has been dug up and washed carefully. Account for the development of so many rootlets.

4. To what family of plants does the Dandelion belong ? Why ? Is the Dandelion a highly evolved plant compared with the Buttercup? Why?

5. Where are the flower-buds found ? Their covering and shape ? Have a cluster of Dandelions under observation for a week or more, and determine *when the buds open; when they close; how often a flower will open; how long a period of sunlight is necessary to make them open.*

6. Study the opening of the *bracts* during the flowering period. Of what advantage to the plant is this opening and closing of the bracts ?

7. Determine the changes in the length of the SCAPE. What purpose is served? Describe the appearance of the flower when opened for the last time.

8. Determine if the stamens mature *before, at the same time, or later than* the stigmas. Make careful drawings of the flower.

9. Study the development of the SEED; describe the changes which take place. Draw a mature seed.

10. Place a long strip of the scape of a Dandelion in a saucer of water. What occurs? Account for the change. Take it out of the water and put it into a solution of salt. What occurs? Why?

[Consult Scott's Nature-Study and the Child.]

### VI. The Leaf.

1. Observe the following details of the leaf as it grows on the plant in the field:

(a) The pattern and individual shape, (b) method of overshading and over-reaching other leaves, (c) adaptation for rain, (d) protection against wind, (e) mechanical support, (f) means of defence against insects and fungi, (g) arrangement for bud protection, (h) autumn coloration.

2. Note any adaptation for gathering the rain of: (a) Groundsel (directing water to base), (b) Common Lettuce, (c) Chickweed (line of hairs along the stem, (d) Ash, (e) Labiates, (f) Grasses.

3. Note any adaptation for protection against storms in the leaf of: (a) Ash (observe on a windy day), (b) Mountain Ash, (c) Beech, (d) Poplar.

4. Note any adaptation as to mechanical support in the leaf of: (a) White Catchfly, (b) Bracken, (c) Blackberry (examine cross-section of petiole).

5. Note any adaptation for bud protection in the bud of: (a) Horse-chestnut, (b) Rumex, (c) Wood-sorrel, (d) Verbascum, (e) Goose Grass, (f) Stachys, (g) Hawthorn, (h) Daisy.

6. Make a collection of leaves showing as many forms as possible. Try to identify the different maples and oaks by their leaves.

7. What is a leaf? What is its main function?

### VII. Leaf Fall and Autumn Coloration.

1. Note the manner of leaf-fall upon as many shrubs and trees as possible, especially those with compound leaves.

2. Determine how long the leaves remain attached in privet, laurel, and the various evergreens.

3. Determine how the leaf separates from the stem. Section leaves attached to their stems early in autumn and observe the development of the "cleavage plate."

4. What is the economy of leaf-fall ?

5. Keep a record of the dates of (1) the beginning of coloring, (2) the color, and (3) the changes of color of leaves in autumn.

6. What is the probable influence of (1) frost, (2) oblique rays of sun, (3) diminishing water supply, (4) lower temperature, (5) declining activities of leaf, in autumn coloration. Discuss.

7. What new buds have been formed? How are they located with reference to the leaf? How many buds to a leaf?

## VIII. Germinating Seeds.

1. Soak seeds of beans, peas, corn, squash, onion for a few hours in water.

2. Observe and draw external appearences, naming the various parts.

3. Compare structure of these seeds.

4. Germinate some of these in moist sand or loose soil, and examine every day for development. Make drawings to show the changes.

5. Determine how the young plants get out of the seed coat in each case.

6. What is the result if the seed is planted upside down?

7. Compare the habits and form of the Cotyledons of the different seeds.

8. As separate problems, determine the influence of warmth, moisture and air on germination, by suitable experiments.

## IX. The Scarlet Runner Bean.

1. Compare with the Wild Cucumber and Pumpkin.

2. Germinate about 100 seeds.

3. Make drawings of the various stages in the germination of the seed. Compare the first pair of leaves produced with those that are produced afterwards. Draw them.

4. Its method of using the tendrils.

5. (a) Note the general shape of the tendrils.

(b) Do they grow rapidly? Measure one and see.

(c) Does the tendril always point in the same direction?

(d) Note the direction it moves.

(e) How far does it move, i.e., through how great an angle?

(f) Does it always move in the same plane? or does it move up and down as well as from right to left?

(g) Is there any advantage to the plant in having its tendrils move through an arc in this way?

(h) Hold your fingers so that it will touch a tendril for five minutes. What happens? Use a stick or lead pencil in the same way.

(i) When the finger or stick is removed does the tendril continue to curl up? Why?

(j) Does it ever straighten out again?

(k) Try one of the old tendrils. Cut it loose and see if it will uncurl again. Why will it not?

6. Nail a little stick just out of reach of one of the tendrils and watch what happens.

(a) Does the plant grow straight towards the stick?

(b) Does the plant act the same as if the stick were not there ?

(c) Is there any attraction in the stick for the plant? i.e., has the stick anything to do with making the plant twine around it?

(d) If there is no attraction between the stick and the plant, why is it the tendrils finally attach themselves to the stick?

### X. Living Plants at Work.

The following simple experiments should be carried out whenever practicable, and their significance determined :

1. Place some soaked beans between two portions of damp carpet felt or thick blotting paper in a plate. Cover the whole with another plate placed upside down, and leave in a warm place. Examine every day, and observe any changes.

2. When some of the seeds have sprouted, mark off on the root and stem with India ink, commencing at the tip, very short equal spaces. Replace seedlings in the damp paper between the plates. Examine every day.

3. Grow some seedlings in the dark.

4. Tie carefully a piece of moist bladder membrane over the end of the bulb of a thistle tube, fill the bulb and part of the stem with a strong syrup of sugar, and place the whole bulb end down in a jar of water, taking care to have liquids at same level in stem and jar.

5. Scoop cavities in a carrot and sugar beet, dry carefully and fill with dry sugar. Set aside for a day or two.

6. Place thin slices of sugar beet in separate vessels of water and 10 per cent. solution of salt.

7. Place thin slices of red mangel, which have been boiled for a few minutes, in a dish of water.

8. Tie some rubber cloth or oiled paper about the pot in which geranium plant is growing and cover the whole with a glass or bell-jar.

9. Cut a shoot of geranium or begonia and place the cut end in a bottle of water colored with red ink. Leave for a few hours, and determine what parts of the stem are stained. Use a magnifying glass.

10. Place two small potted plants, one on each pan of a balance. Place a bell-jar over one of the plants. Counterpoise. Observe results.

11. After a few hours take off bell-jar, wipe the moisture carefully from inside and replace. Is balance restored? Explain.

12. Tear off a small strip of epidermis from the lower surface of a leaf, place in a glass side, and examine with a microscope. Note the breathing pores, their shape and number.

13. Boil for a few minutes in water some green leaves; remove and immerse in alcohol until bleached. Notice color of solution. Place bleached leaves in tincture of iodine solution. What happens and what does it indicate? Try variegated leaves.

14. Test in the same way some leaves which have been kept in the dark for a few days.

15. Place some water-cress or other water plant in a jar of water and put in a sunny position. Contrive some way of collecting the gas and test it.

16. Place some soaked peas in a tall jar. Cover tightly with a piece of glass. Test the gas in the jar after 24 hours with a burning match. What is it?

17. Cover a potted plant with a bell-jar. Within place a beaker of clear lime-water and leave the whole in a dark room for a few days.

18. Place a potted plant or some seedlings near a window and leave for a few days without disturbing.

19. Observe the attitude of young sunflowers during a bright day.

(Consult Atkinson's First Studies of Plant Life).

## XII. The Conifers.

1. What Conifers have their dry, thin bud-scales about the base of the leaves?

2. What Conifers have their needles single, but arranged on all sides of the stem? Arranged in two rows on the stem?

3. What Conifer has single, flattened leaves, inclined to turn upward so that the under side of the stem is nearly bare?

4. Determine how the cones of the different species stand; their size; their time of maturing; and when they cast their seeds.

5. Make short descriptions of the Conifers on the College Campus with regard to (1) *their leaves;* (2) *their cones;* (3) *their bark;* (4) *their habit of branching.*

6. Determine the position of the *fertile* and *sterile* flower clusters on the stems of (1) Larch; (2) Juniper; (3) Yew; (4) Arbor Vitae; (5) Pitch Pine; (6) White Pine; (7) Scotch Pine; (8) Austrian Pine; (9) Norway Spruce.

7. Study the young cones and draw them.

8. How can you tell the age of a Conifer? Ascertain how long the leaves remain attached to the twigs of the Conifer.

### XIII. The Wood of Coniferous Trees.

1. In cross sections determine (1) whether the heart-wood and sapwood are of the same color; (2) whether "autumn wood" is of the same color as the "spring wood."

2. Make diagrammatic sketches to illustrate.

3. Study the specimens in the laboratory.

4. Make a key for identification of different coniferous woods.

5. When are "spring wood" and "autumn wood" formed?

### XIV. Logs, Lumber, and Knots.

1. Study the end of a large log of hard wood, and determine the areas: bark, wood, and pith. Make a drawing.

2. Where does a tree grow in thickness? Where is the oldest part of the wood?

3. What does each ring represent? Why? Why is the pith sometimes not exactly at the centre?

4. Of what is the bark mainly composed? How does the inside part differ from the outside? What is the use of the bark to the trees?

5. What is the meaning of the numerous fine rays (medullary rays) leading out from the pith? Are all of the same length? Do they extend into the bark?

6. Determine in which direction the wood splits most readily. Explain.

7. When a log is sawed into boards, will the "grain" of the boards differ according to the way the boards have been sawed? Show clearly by specimens and by drawings.

8. How is "quarter-sawed" lumber obtained? Why is it more expensive than other cuts? Why is it admired in furniture?

9. Examine a tree which has lost a branch (by accident or by pruning). What is happening to the cut end of the wound? Any diseased wood? Why does not the new wound-tissue (callus) always completely cover over the wound?

10. When lumber is sawed from a log made from a tree which has been deprived of branches at some stage of its existence, should you expect to find traces of such branches? What are they called in lumber? Explain the formation of "buried" knots.

11. Find out the various processes by which lumber is made up into furniture.

12. Where are the chief lumber regions of Canada? Why has the price of lumber advanced within recent years?

[Consult Percival and Bailey.]

### XV. The Apple Twig.

1. Note the rings on main branches and twigs; cause? age of twig?

2. Examine branches of different ages, and compare the markings and buds.

3. From what buds are the longest growths? Why?

4. Observe the short branches with broken ends; what are these called? Why do not these bear fruit every year? What becomes of the buds formed on the spurs not bearing fruit? What is the cause of the broken ends?

5. Find out the following:

(1) Age of the twigs studied.

(2) Number of apples each fruit-spur bore.

(3) The fruit-spurs for next season.

(4) Where the blossoms did not set.

(5) Where the apples fell before maturity.

(6) Where terminal buds were injured, and lateral buds developed into fruit-buds.

(7) Any accidental markings.

(8) The dormant buds.

[Consult Bailey's Lessons with Plants.]

### XVI. Spurs.

1. Examine and collect twigs of the various orchard and forest trees.

2. Determine the position of the fruit-spurs on the different twigs. Make careful drawings.

3. Write the story of each of the branches.

4. Some trees have few or no spurs and bear almost entirely on long shoots one year old; other trees produce their fruit-buds chiefly on the apex, or on the sides of spurs, the long shoots of the tree bearing only wood-buds the first year; while others bear almost equally on both long shoots and spurs.

Give examples of the three classes given above.

5. How do the red currant and gooseberry bear their fruit-spurs?

6. Determine if possible the age of fruit-spurs in the different trees studied.

7. What is the importance of a knowledge of fruit- spurs to the orchardist?

### XVII. Trees.

1. Common Name, Scientific Name, and Family.

2. The tree from a distance in early spring or winter.

(*a*) The contour, habit of growth, or general outline of the tree, whether *pyramidal, spreading and rounded, pillar-like, symmetrical, or one-sided.*

(*b*) The color of the foliage.

3. The tree at close quarters.

(*a*) *Trunk.* Circularity, straight or crooked, or tapering, excurrent deliquescent, indications of disease or decay, size.

(*b*) *Bark.* Rugged or smooth; brown, gray, or silver white; any tendency to peel off in scales or come off; any lichens, moss or fungi.

(*c*) *Branches.* Whether inclined to the stem at an acute or obtuse angle; general difference between upper and lower branches; whether drooping, or have an upward trend or a downward curve; whether the twigs are one-sided, or on both sides of the main branch; whether alternate or opposite.

(*d*) *Twigs.* Whether crooked, rough-barked, indicating slow growth; or straight, smooth-barked, indicating quick growth; study of transverse section of twig, noting bark, wood and pith and annual rings and medullary rays; examine the buds, and note their relative positions, shape, color, scales, rudimentary leaves and flowers; relation of bud arrangement to branching, and the branching to the ultimate form of the tree; study of leaf-scars; study of bud-scale rings and age of the tree.

### XVIII. The Woods of Dicotyledonous Trees.

1. The object of this study is the identification of the woods of our common trees. Transverse sections of twigs $\frac{1}{2}$ to $\frac{2}{3}$ inch or more should be made, and with the aid of a lens determine (1) whether there is any diffrence in density between the spring and the autumn woods; (2) whether the vessels are distinctly visible or hardly visible; (3) whether the medullary rays are wide and quite visible to the naked eye; (4) the color of the wood and medullary rays.

2. Make diagrammatic sketches to illustrate the difference between the various woods.

3. Study the specimens in the laboratory.

4. Try and make a key by means of which the woods can be identified.

### XIX. The Development of the Apple and Cherry.

This involves a study of the ovary and its changes during the formation of the fruit. Sections of different specimens should be made at frequent intervals, and a series of drawings, kept with their accompanying dates.

1. Make longitudinal and transverse sections of the flowers of an apple. Observe the position and extent of the receptacle and the calyx-tube. Such observation should be made every two days.

2. Determine from your studies the formation of the apple,—the part occupied by the calyx, receptacle, and ovary-wall respectively.

3. Cut sections both longitudinal and transverse of the ovary of the cherry from the time the flower fades up to the time the fruit is quite large. Note especially the growth in thickness of the parts of pericarp, viz., the endocarp or "stone," and the mesocarp or "flesh."

### XX. The Rose Family.

1. Collect, dry, and mount as many specimens of the Rose family as you can find.

2. Examine carefully the flowers of each, and make longitudinal, vertical sections of each.

3. Make careful drawings of the vertical sections,—the object being to determine the cohesion and adhesion of the parts of the flower.

4. Group all the forms studied into three: the *apple group;* the *strawberry group;* and the *plum group.*

5. Try to determine the relationships of the forms studied.

6. Compare a raspberry with that of a strawberry. Watch their growth after the flower fades.

7. Watch the development of the ovary of a plum when the flower begins to fade. What becomes of the receptacle?

The following forms at least should be studied: apple, plum, strawberry, spiraea, cherry, june-berry, raspberry, wild rose, hawthorn, pear, cinquefoil, barren strawberry, blackberry, mountain ash.

### XXI. The Legumes.

Some Special Studies (Spalding):

(*a*) Arrangements for cross-fertilization.

(*b*) Extent to which the production of seeds of RED CLOVER is dependent on the agency of insects.

(*c*) Capacity of the COMMON PEA for self-fertilization.

(*d*) Occurrence of modified leaves, such as tendrils.

(*e*) Morphology of protective structures of various leguminous plants, e.g,. spines of locust and honey locust, hairs of desmodium, etc.

(*f*) Sleep movements of Clover, etc.

(*g*) Causes of the wide distribution of the family.

1. Classify the legumes of the farm according to their leaves, noting whether the leaves are (1) PINNATE, ending in tendrils; or (2) PINNATE with two or more pairs of opposite and one single terminal leaflet; or

(3) leaves with three leaflets; or (4) leaves DIGITATE with more than three leaflets.

2. Study the legumes of a farm. Make a list of the forms.

3. Collect and study the various CLOVERS to be found in the Experimental grounds. In what respect does the young seedling Red Clover differ when grown with cereal crops than when grown alone? Is alsike a hybrid, as its scientific name would imply, (*Trifolium hybridum*)?

4. Watch carefully the flowers of *white clover* (*Trifolium repens*), and determine how such flowers are fertilized; what occurs to each flower after fertilization; how the unfertilized ones (old maids) can be told?

5. Which species of clovers are *annuals, biennials, perennials?* Which are upright growers and which are creeping?

6. Compare the *Medicagos* with the Clovers. Is Black Medick a weed?

7. Compare the *Melilots* with the Clovers. Is White Melilot a weed?

8. Contrast the *Peas* and the *Vetches*. Compare their flowers, and note any points of difference between them. What difference in germination? Make drawings.

9. Collect and preserve the tubercles of the various legumes.

### XXII. Grass Investigations.

1. Collect samples and bundles of the various wild and cultivated GRASSES.

2. Determine the following regarding each GRASS:

(*a*) The time of Flowering.

(*b*) The height of growth.

(*c*) How it withstands drouth.

(*d*) How it withstands excess of water.

(*e*) How it withstands pasturing.

(*f*) Its palatability.

(*g*) Its roots, habits, whether creeping, or tufted.

(*h*) Its duration, whether annual, biennial, or perennial.

3. Make germination experiments of as many grasses as possible, and study the habits of the seedlings.

4. Collect samples of commercial grass-seed from various seed houses, and determine the *purity and vitality*.

### XXIII. Recognition of Grasses by their Leaves.

1. Ascertain how the leaves are folded in the bud, whether (a) simply folded, or (b) rolled. *Poa pratensis* (June Grass) is folded, and *Phleum pratense* (Timothy) is rolled.

2. Ascertain if there are clasping claw-like appendages at the base of the leaf. *Lolium perenne* (Perennial Rye Grass) and *Festuca pratensis* (Meadow Fescue) have such claw-like appendages, while Fox-tail has none.

3. Ascertain the color of the leaf sheaf below ground.

4. Ascertain whether the leaves are cylindrical or flat; narrow or broad, prominently ribbed or not; the color of the veins.

5. Ascertain whether the leaf-sheaths are smooth or hairy; keeled or not.

6. How do fruit-growers control the Codling Worm?

7. Describe and draw a "scabby" apple. What are the objections

8. Make a *key* by means of the characters of the leaves.

### XXIV. The Apple as a Host.

Secure specimens of "wormy" and "scabby" apples.

1. How many kinds of apples do you know?

2. Is there a difference in the size of the cores of different apples?

3. Cut crosswise and lengthwise of two apples. Answer the following questions and draw:

   (*a*) How many cells in the core? How many seeds in each cell?

   (*b*) How do the seeds point? Are they attached?

   (*c*) Is the blossom end connected in any way with the core?

   (*d*) From what part of the flower has the apple (fruit) been derived.

4. Write out an account of the work of the Codling Worm. How many broods in a season? How does it spend the winter? Collect the different stages of this insect.

5. Where did the worm leave the apple?

6. How do fruit-growers control the Codling Worm?

7. Describe and draw a "scabby" apple. What are the objections to scabby apples? Determine how and where infection takes place, and the development of the disease.

8. How do fruit-growers control the "scab"?

9. Make a collection of other enemies of the apple.

### XXV. Fruits.

Collect for comparison and study the fruits of most of the common plants in the vicinity.

1. Group them into (1) *dry*, and (2) *fleshy* forms.

2. Group all the dry fruits into (1) Dehiscent, and (2) Indehiscent forms.

3. What is the general name for a dehiscent fruit? What is the pericarp?

4. Group the dehiscent forms into (1) those derived from a simple one-celled ovary, and (2) those derived from a compound several-celled ovary.

5. Examine the indehiscent fruits; determine how they have developed from the ovary, and make out the changes that have taken place while maturing.

6. Group the fleshy fruits into (1) berries, drupes, pomes, hips, haws, and pepos.

7. Study the fruits of the evergreens; compare them.

8. Study the fruits of the ferns, club-mosses, and mosses.

9. Account for the brilliant colors of some of the fruits.

10. Why is unripe fruit usually green?

11. Why are the seeds of many fruits unpleasant to the taste?

12. Why have some fruits a hard coat next the seed?

13. Why are the seeds of some fruits very small?

14. Why are the edible portions of nuts protected by a shell, and unprotected in berries and such fruits?

## XXVI. Nuts.

Collect specimens of hazelnuts, beech nuts, chestnuts, hickory nuts, walnuts, and butternuts.

1. Are all of these fruits? Why? Are they dehiscent or indehiscent? Why?

2. In the case of the first three, of what is the "bur" composed? Does it dehisce in all three?

3. In the case of the last three, of what is the "shuck" or "hull" composed? Does it dehisce in all three?

4. How many cells and seeds does each nut contain? In the chestnut, for example, there are sometimes two kernels in a nut. Explain.

5. What change has taken place in the wall of the ovary of each nut in the process of ripening?

6. Give a botanical definition of *nut*. Is the acorn a nut? Is the horse-chestnut a nut?

7. Why are nuts usually dull colored?

8. Why is the edible portion of nuts protected by a shell?

9. How are the nuts distinguished?

10. How are unripe nuts protected while on the tree?

11. Study the common commercial nuts, such as are sold on the market.

### XXVII. Dissemination of Seeds.

Make a collection of seeds, and examine carefully. Answer the following questions:

1. Why do so many seeds have special growths attached to them?

2. Arrange and name the seeds collected according to whether they have

   (*a*) Barbs or grappling devices.

   (*b*) Provision for floating on water.

   (*c*) Provision for floating in the air.

   (*d*) Mechanism for ejection.

   (*e*) Juicy parts attractive to animals.

3. Observe carefully and record the special adaptations to distribution possessed by: Witch-hazel, touch-me-not, dandelion, burdock, beggar-ticks, blueweed, white pig-weed, cherry, basswood, sedge, pine, milk-weed, maple, poison ivy.

4. Why are the seeds of most weeds dull colored?

5. What are the main methods of dissemination of weed seeds?

6. What birds are largely instrumental in dissemination of seeds?

[Consult Beal's Seed Dispersal.]

### XXVIII. Domestic Animals.

1. Compare the dog, cat, cow, horse, and sheep as to (a) habits of feeding, (b) coverings, (c) shape of limbs, (d) mode of using the limbs, (e) their paws or hoofs, &c., (g) teeth, (h) shape of head.

2. What animal was probably first domesticated or tamed?

3. Study carefully the dog: Kinds—shepherd dog, coach dog, hunter, &c.; as companion or playmate; care of dogs, intelligence, and fidelity; strong senses of hearing and smelling; character of paws and claws; what wild animals are related to the dog?

4. Study the *cat*, comparing it with the dog as to intelligence, form, use, manner of walking, senses, affection, paws, and claws, tongue, bad habits. What wild animals are related to the cat?

5. Study the *cow*: What kind of food does it eat? How does it eat? What is the "cud"? What are *ruminants*? Name some ruminants. Of what use are the horns? What are some of the uses of the living cow? Of the dead cow? How does the cow lie down? Get up?

6. Study the horse: Importance in commerce and war; to civilization; kinds; intelligence; dentition; kind of food, manner of eating; feet, the way the horse lies down and gets up; care of horses; origin; wild horses. What wild animals are closely related to the horse?

### XXIX. Animal Movements.

1. Study the way the following animals walk: Horse, cow, cat, dog. In what order are the feet placed in walking? In trotting? In galloping?

2. Study the movements of an earthworm, a clam, an insect.

3. Study the movements of a fish, a snake, and a bird.

4. How does a rabbit run? A robin or a crow walk?

5. To what extent has the need for getting food affected the manner of movement of animals? Study cat and dog.

6. To what extent has the place where food is obtained affected the movement? Study fish, bird, earthworm, clam.

7. To what extent has the need for escape from enemies affected the mode of movement? Study rabbit, squirrel.

### XXX. Animal Coverings.

1. Compare the natural coverings of man, horse, cow, rabbit, cat, pig, sheep, mink, hen, turtle, snake, frog, fish, caterpillar, and earthworm. Name those covered with hair, with fur, with wool, with feathers, with scales.

2. What is the use of the covering? Does it vary from season to season in different animals?

3. What is the difference between fur, hair, and wool?

4. Where do fur-bearing animals live? Where animals with hair?

5. What is the arrangement of the feathers on a bird? What is the special advantage of feathers as a covering?

6. Compare the winter plumage with the summer plumage of birds.

7. How are the scales of a fish or snake arranged? Of what advantage?

8. What is peculiar about the coverings of insects? How can insects grow with such coverings?

9. Why does a snake shed its skin? How often?

10. To what uses are the coverings of animals put? Specify.

### XXXI. Food-Getting Among Animals.

1. Study the ways the horse, cow, sheep, cat, and dog seize their food.

2. What animals use their fore limbs in eating? What do not?

3. What animals are flesh-eaters? What are plant-eaters?

4. Study the dentition of rabbit, cow, horse, sheep, and man. What are the names of the different kinds of teeth and the use of each?

5. Study carefully how the cat eats its food. What other animals eat their food in the same way ? Of what use is the tongue ?

6. How does the dog and cat take liquid food ?

7. What animals get their food at night ?

8. What is the food of the earthworm and how does it take it into its body ?

9. Watch how a snake takes its food, a frog, a caterpillar.

10. To what extent do the kind of food and the food-getting affect the shape of the head and jaws ?

11. Does the food supply affect the habits of animals at different seasons ?

12. Determine whether the following animals are beneficial or injurious: Mole, snake, toad, sparrows, hawks, owls, woodchucks, squirrel, weasel, racoon, rat, mouse, plant-lice.

### XXXII. Adaptations Among Animals and Plants.

1. In what particular is the *cat* adapted for (a) securing food, (b) protecting itself, (c) defending its young, (d) in fighting with another cat or other animals, (e) its surroundings ?

2. Study the adaptation of the squirrel, the hawk, the horse, the giraffe, the deer, the mole, to their respective mode of life.

3. Find examples of caterpillars and other insects which are protected by their color. What higher animals are protected in this way ?

4. How are the skunk, the porcupine, the wasp, and the bee protected ?

5. To what extent are fishes, birds, reptiles, and worms adapted to their mode of life ?

6. Find plants that are well adapted to their particular mode of life.

7. What are some of the means plants have of surviving under unfavorable conditions ?

8. Explain how all plants and animals are adapted to their surroundings ?

(Read "Animal Life" by Jordan and Kellogg: Appleton).

### XXXIII. Snails and Slugs.

These animals belong to the sub-kingdom Mollusca, (mollis, soft; esca, flesh). Why ?

Slugs have an internal flat shell, while snails have one coiled internal valve.

1. *The Shell.* Find all the different kinds of snails you can. Rest the shell on its base with the aperture pointing toward you, and draw a plan of the spiral. Does the spiral run to the right or to the left ? In a

right handed dextral shell, Helix, Limnaea, in this position the aperture is to the right of the axis. Or imagine such a shell a spiral stair-case, as you ascend, the axis of the spire will always be on your left. Can you find any left-handed (sinistral) shells ? (Physa). All whorls nearly in the same plane, (Planorbis). How many whorls are there in the spiral ? (The largest is the body-whorl, where most of the soft body of the snail is protected, the rest is the spire.)

Observe the lines of growth running parallel with the opening in the shell. Note the color and surface markings. Can you see, a few well-marked lines often separating off areas of different depths of color ? These each distinguish one year's growth from another. How old are your specimens ?

Break out a piece of the shell from the edge of the body whorl. Is the gap filled in, or is the new piece of the same color as the rest of the shell ? Try the same experiment again removing parts of shell from the body-whorl, not from the edge but from the spire. How long does reparation require ? Is there any protective coloration ?

2. *Locomotion.* Snails and slugs belong to the class *Gastropoda* (bellyfooted) as foot is on the ventral surface of the body. Let snail crawl on a piece of glass, and watch its movements from the under side with a lens. Do you see a wavelike motion? Which way do the waves move ? Why can snail hold on to a surface so firmly ?

3. *Head.* How many horns on the head ? Describe them. Where are the eyes. Are some of the tentacles more sensitive to touch than others ? Watch mouth and its motions. Observe how it feeds. Can you see tongue (radula) as a Helix rasps off the epidermis of a lea ? (The radula ribbon is covered with thousands of minute sharp teeth).

4. *Respiration.* Observe the opening to the lung on the right side of the body. What movements of the aperture occur ? Will Helix live in water ? Will Limnaea live long totally submerged, and completely deprived of air ?

5. *Food.* Try feeding experiments with Helix, Limax, and Limnaea. Try leaves, dry leaves, soap, dead bodies of snails and slugs, and other species; lichens, mayflies, coleoptera; raw beef, fungi. Will Limax bite your hand ? Try tender skin between fingers.

6. *Regeneration.* Do lost tentacles, eyes, parts of the foot grow out again if cut off ?

### XXXIV. The Sundew.

1. Observe the habitat and general habit of the sundew.

2. Draw a leaf, showing the tentacles.

3. Grow sundew in shallow wooden dishes containing peat, and kept in a room at a temperature of 70 degrees F.

4. "Place pieces of rotten wood, boiled meat, or boiled egg, or bits of glass no longer than a pin head, on the tips of the glands of the tenacles at the margin of the leaves," and watch the result.

5. How long before movement takes place ? Use a lens.

6. Does relaxation of the movement occur while the object remains on the tentacle ?

7. Do all the objects mentioned secure equal reactions ?

8. How is the amount of secretion influenced by the different objects ?

9. Place a small cube of 1 mm side, with sharply cut edges, of the white of a hard boiled egg on each of several sundew leaves, and determine if the albumen is digested after a day or two.

10. Determine the structure of a tentacle, using a microscope. Observe the spirally thickened wood-fibres, or "water-pipes."

11. Try the action of very dilute solutions of ammonium salts on the bending of the tentacles.

12. Try the action of sugar, starch, dilute alcohol, milk, mucous, and saliva.

13. Are the stalks of the tentacles sensitive ?

14. Repeat Francis Darwin's experiments as to the effect of feeding sundew with roast meat (1-50 grain) on the nutrition and reproduction of the plant.

## XXXV. The Wheat Rust.

1. Collect specimens of diseased barberry leaves, and determine when the cluster-cups are mature.

2. Make careful drawings of the cluster-cup.

3. From the mature cluster-cup remove some spores to a moistened leaf seedling of wheat or oat plants.

4. Determine when the rust appears on the wheat or oat leaves after inoculation.

5. Inoculate other wheat plants and other oat plants from the first inoculated plants.

6. Try to get specimens of wheat or oats infested with Black Rust, and which have wintered over in exposed places. Determine how the Black Rust spores germinate.

## XXXVI. The Life History of the Toad or Frog.

1. Collect the eggs at the river in early spring. About how many eggs are laid by one toad ? What is the difference between the toad's eggs and the frog's eggs ? Keep the eggs in a flat glass dish in water and watch them hatch. Change the water every two or three days. Draw a few eggs.

2. Draw the tadpole in its various stages of development. Note some of the habits of the tadpole, how it swims, breathes, etc.

3. Test them with various kinds of food.

4. Note the development of the legs.

5. What becomes of the tail ?

6. Examine its eyes. Has it any eye-lids ?

7. Study the habits of the frog.

8. What does it eat ?

9. How does it breathe ?

10. Does it ever drink ?

11. Experiment. Dreprive a toad of water for a day and weigh him carefully. Next sit him on a wet blotting paper for an hour or two and weigh again. What is the increase in weight due to ?

12. Note its humpbacked body and its sitting posture.

13. What are the natural enemies of tadpoles ?

14. What are the natural enemies of the frog ?

15. Since so many eggs are laid by each female frog, and nearly all these produce tadpoles, how do you account for so few frogs ?

16. Of what economic value are toads ?

17. Write a short account of the life history of the toad, and compare with that of the frog.

18. How many kinds of frogs in your vicinity?

## XXXVII. Mosquitoes.

1. Collect some larvae of mosquitoes in stagnant water, and place them in a glass jar for observation.

2. Watch carefully the habits of the larvae,—how they breathe, how they swim, and whether heavier or lighter than water.

3. Make drawings of the larvae.

4. How long do the mosquitoes remain in the larval stage?

5. Study carefully the pupa stage,—how it differs from the larval, how it breathes, etc.

6. Watch the escape of the adult mosquito. Describe the operation. What state of water is necessary ?

7. Are all the larvae exactly like ? the pupae ? the adults ? What difference between the male and female ?

8. Secure specimens of Culex, of Anopheles, both males and females.

9. Try simple experiments on the killing of the larvae with oil.

10. Endeavor to get the eggs of mosquitoes. Draw the egg mass.

11. Ascertain the exact duration of the different stages of the mosquito.

## XXXVIII. Some Underground Growths.

Collect typical samples of potato tuber, carrot, turnip, and mangel or beet,—

1. Examine the arrangement of the "eyes" on a large potato tuber, and note where they are most numerous.

2. Cut longitudinal and cross sections passing through an "eye."

Make drawing, and determine the nature of an "eye." How many buds in an "eye"?

3. What reasons have you for supposing the tuber to be a modified stem? Illustrate by drawings. Locate the cortex, epidermis (periderm), vascular cylinder, cambium ring, and pith. Where is the wood?

4. What is the chief reserve food stored in the tuber? How would you test its presence?

5. Do the true roots rise above or below the tuber-bearing branches in field?

6. What is the advantage of exposing the tubers for planting to light for a week or more?

7. What is generally the shape of the carrot? How are the small secondary roots arranged?

8. Make longitudinal and cross sections of a carrot? Note color, thickness, and texture of the various parts. Draw.

9. Has a carrot a root or a stem structure? Where is the base and the cortex? the wood? the cambium-ring?

10. What is the difference between (1) the root of cultivated and wild forms of carrot, and (2) the first and second year's growth?

11. Make longitudinal and transverse sections of a turnip. Draw. Note color, thickness, and texture of the various parts.

12. Locate bast, cambium and wood. Of what is the wood composed?

13. Make longitudinal and transverse sections of a mangel or beet. Draw; note color, thickness, and texture of the various tissues and soft parenchyma. Which parts are colored? Name the parts as seen in sections.

[Consult Percival's Agricultural Botany.]

## XXXIX. Spiders.

Field excursions should be made for the study of the work and habits of spiders. A few spiders may be brought into the class-room and placed in the terrarium, where their habits can often be readily observed.

1. Find *orb-webs, funnel-webs, cob-webs,* and the threads of the *balloon spiders.* Make drawings of the structure of each web, and note where each web is found.

2. Where does the funnel-web spider lie in wait for his prey ? What is the appearance of this spider, and what is the structure of the web ? Observe and describe the tunnel.

3. How does the orb-web spider or weaver make his web ? How many kinds of silk are used ? How is the spiral thread arranged ? Where does the spider lie in wait for its prey ? How does the spider pass from one side of the web to the other?

4. What is the structure of a *cob-web* ?

Where and how does the spider lie in wait ?

5. Find, and study *jumping spiders, running spiders, ballooning spiders ;* harvestmen.

6. Observe how the silk is spun by the spiders.

7. Collect the egg-sacs of spiders, and note where they are found. Determine when the eggs hatch.

8. Compare a spider with an insect. In what respect do they differ?

[Consult Comstock.]

### XL. Plant Galls.

Collect the Galls on as many different plants as possible, and make drawings of their shape and contents.

Try and answer the following questions :

1. What galls have openings ?

2. What galls are single-celled ? Many-celled ?

3. What galls become empty before the close of autumn ?

4. Find examples of galls on roots and stems.

5. Study carefully the Pine-Cone Willow-Gall, and give a reason for the Cone. Keep some of these Willow-Galls in a jar, covered with cheese cloth, until spring.

6. Put away also some of the Mossy Rose-Galls and Oak-Galls.

7. Classify the galls collected according to the insects producing them. Which were made by aphids ? by Hymenoptera (Cynipids) ? by Diptera (Cecidomyia) ? by moths ? by mites ?

8. How were the galls made ?

9. Compare the galls found on Golden Rod ; on Oak ; on Maple ; on Elm ; on Grape ; on Witch-hazel ; on Poplar ; on Hickory ; on Rosa ; on Rubus.

### XLI. Earthworms.

1. Prepare a wooden box with holes on side to admit air ; almost fill the box with rich, moist earth, in which are many decaying leaves and stems ; place some earthworms on the surface ; moisten the earth occasionally.

2. Observe the habits of the worms in the box, how they bore through the earth; why they come to the surface after rain.

3. Examine worm-casts,—their shape, whence they came, and how they are brought to the surface.

4. Determine how a worm crawls,—

5. Examine the front end; does the worm always travel the same end foremost ?

6. Examine the home of the earthworm, using a trowel to remove the layers of earth; what is found in the holes ?

7. Find out the kind of food the worm likes; try different kinds.

8. Are roots of plants eaten by earthworms ? Where are worms most abundant ?

9. Determine the sense-organs of earthworms:

(*a*) Note the quickness with which they retreat when disturbed by a heavy step on the earth near their burrows. What sense has warned them of the approach of danger: seeing, hearing, or feeling ?

(*b*) Note the force with which they cling to their burrows when an attempt is made to drag them out.

How is it they cling so strongly ?

Examine the sides and under surface of the worm for an additional cause.

(*c*) Can they see ? Test by bringing light towards them.

(*d*) Can they hear? Test by yelling close to one or beating a tin pan.

(*e*) Can they smell? Test by hiding a piece of its favorite food which you have already determined by experiment, and note whether it finds it.

10. Determine the general appearance of an earthworm.

11. Find the eggs of earthworms; the sac which contains them.

Watch a rich piece of lawn well, before dusk, and, with lantern in hand, watch carefully the habits of the worms which come to the surface after dark.

## XLII. The Songs of Insects.

Collect some crickets, locusts, katydids, meadow grasshoppers, and tree crickets, and place them in a terrarium in which there is some green grass.

1. Determine if both males and females sing.

2. Observe carefully, and determine how each singer makes noise.

3. Find where the "ears" are situated.

4. Try and procure a Cicada, and determine how it makes its peculiar song. Is the singer male or female?

5. What other insects make noises?

### XLIII. An Ant's Nest.

Prepare an ant's nest (see Comstock's Insect Life, p. 279).

1. Are all ants' nests alike? In what situations have you found them?

2. Describe a nest.

3. Describe the appearance of the different kinds of ants in a nest. What is the duty of each kind?

4. What are the white bodies seen in the nest?

5. When have you seen winged ants? Try and find an ant ridding itself of its wings.

6. Make a collection of all kinds of ants you have seen.

7. What relationship have you noticed between ants and aphids?

8. What is the best way of ridding a room of ants?

### XLIV. The House-Fly.

1. Why are house-flies more abundant in September than in early summer?

2. Watch a fly feed. How does it take its food? As a solid or a liquid? Does it make use of its feet while feeding? How?

3. Determine the structure of its mouth. By pinching a fly's head gently the mouth parts will protrude. Examine with a lens. Draw.

4. Draw the house-fly while it is resting on a piece of paper. Name the parts.

5. Where do house-flies deposit their eggs? Observe the creatures that hatch from the eggs. What are they called? Find the next stage. Preserve these in a box. What are these called?

6. Catch some of the flies that bite before rain. Are these house-flies? Examine carefully, and look at mouth parts.

7. Examine a fly's foot and try to account for its clinging to ceiling.

8. Collect other flies that frequent the house and determine the difference between them and the house-fly.

### XLV. The Currant Saw-Fly.

1. Collect, draw and examine the leaves of the currant on which are deposited the eggs of saw-fly.

2. Note the location of the eggs on the leaves.

3. Collect some of the adult insects and pin them in your collection.

4. Determine the duration of (1) egg stage, (2) larval stage, (3) pupal stage.

5. Describe the mode of feeding of the larvae.

### XLVI. The Pear Tree Slug.

1. Find some of the eggs, and if possible some of the females ovipositing. What is the shape of the egg?

2. How many eggs to a leaf?

3. Examine larva and its manner of feeding.

4. Its duration as larva. Number of moults.

### XLVII. The Spruce Gall-Louse.

1. Examine carefully some infested twigs of white spruce, and determine the shape of galls.

2. Watch for the deposition of eggs in woolly coverings about May 10th.

3. Draw egg masses. Estimate the number of eggs.

4. How long before the eggs hatch?

5. Watch the grey lice for five or six successive days, and determine how the galls are made.

6. What are the best means of combating the gall-lice?

### XLVIII. The Oyster-Shell Scale.

1. Collect specimens of twigs infested with Oyster-Shell scale, and determine what stage of its history the insect is passing through.

2. Make careful drawings of the adult and young of this insect.

3. Try to find out how far the young would move from the mother scale before it settles down—about June 1st.

3. Determine if you can the duration of each moult.

### XLIX. The Larch Saw-Fly.

1. Search carefully in the soil in the larch grove for dark-brown oval objects, and take them to your room; place them in a box and await developments.

2. Describe carefully the adult saw-flies. Any difference between sexes? Pin several for your collection.

3. Observe the females depositing their eggs. Describe the process. How many eggs in the group? Make a drawing of the eggs in place on the twigs. Account for the bending of the twigs.

4. Determine the duration of the egg stage, the number of moults of the larva, the duration of each moulted stage, and any differences between the different moults. Collect specimens of the different moults for your collection.

### L. The Potato Beetle.

1. How does the insect pass the winter? When did you first see the adult?

2. Determine the date of the first appearance of eggs. How many in a cluster? How long to lay the eggs? How long in the egg state before hatching? Color? Collect. Where are the eggs laid?

3. Observe the larva in its different moults, and the duration of each moult. Collect the pupae.

4. Describe the full life-history.

### LI. Lady-Bird Beetles.

1. Collect as many kinds of Lady-Birds as you can, taking notes of what they were doing when you collected them.

2. What other insects did you find on the same plant?

3. Collect as many Lady-Bird larvae as you can, and preserve them in vials for reference and study.

4. Identify the Lady-Birds collected by means of Comstock's Manual and other reference works.

5. How are Lady-Birds distinguished from leaf-eaters (Chrysomèlids)?

6. Determine where the pupa is formed and how.

7. Of what advantage to the Lady-Birds are their bright colors?

8. Make drawings of the most commonly occurring lady-beetles, showing the variations and marking.

9. What Lady-Birds do you find in the greenhouse in scale-infested plants, or on apple trees infested with Oyster-Shell Bark Lice?

10. What Lady-Birds do you find on trees infested with *aphis*?

### LII. Some Common Autumn Insects.

Make a collection of as many members of Orthoptera as possible; classify, and name them.

2. Observe the habits of *cockroaches, long-horned grasshoppers, short-horned grasshoppers,* and *crickets*.

3. Determine where they spend the winter.

4. Describe how the grasshoppers and crickets deposit their eggs.

5. Collect "woolly bears," milkweed caterpillars, dagger caterpillars, tiger caterpillars, fall web-worms, and cabbage worms. Place them in separate boxes and feed them their appropriate leaf-food. Watch carefully from day to day for developments.

## LIII. Birds.

In the study of birds the student should determine the following points :

(a) size, (b) color, (c) markings, (d) shape of body, bill, wing, tail and foot, (e) appearance, (f) movements, (g) flight, (h) localities frequented, (i) food, (j) song, (k) habits, (l) nest, (size, form, material building), (m) eggs, (n) incubation, (o) young. Record in a note-book.

1. Keep a bird Calendar, such as the following :

| Name of Bird. | When First Seen ? | How many were seen ? | When it was next seen ? | When did it become common ? | When it was last seen ? | Is it common or rare ? | Does it breed near station ? | Remarks. |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

2. Make a list of birds which pass during the Fall Migration.

3. Study carefully the *English Sparrow*.

(*a*) Describe the appearance. Compare the male and the female.

(*b*) Where do sparows build their nests? Color ot eggs?

(*c*) Do you find as many sparrows in the country as in the city?

(*d*) Notice the food habits of sparrows during each of the fall and winter months. What seeds have you seen them eat?

(*e*) Where do sparrows roost? How many in one place at one time?

(*f*) Does the English Sparrow molest any other bird?

(*g*) Is it a friend or a foe?

4. Study carefully the *Common Crow*.

(*a*) Describe the appearance, size, etc.

(*b*) Watch a crow flying. Note the peculiarities of flight.

(*c*) Do crows winter in this district? Find the "crow dormitory," if any.

(*d*) Notice the food habits of crows. What food have you seen crows eating?

(*e*) Describe a crow's nest, and the eggs and nestlings.

(*f*) Compare plumage of young and old crows. Do males and females differ in color?

(*g*) Discuss the intelligence of the crow. Give evidence.

(*h*) Is the crow a friend or a foe?

5. Study carefully the *Woodpeckers*.

(*a*) How many species have you seen? Name them.

(*b*) Describe the appearance of each.

(*c*) Note the holes made by the *Supsucker*. How are they arranged? What is the object of the holes? Is it a friend or a foe?

(*d*) Watch the *Red-headed Woodpecker;* what is the nature of its food?

(*e*) Describe and draw the Red--headed Woodpecker.

(*f*) Compare the *Downy* and *Hairy Woodpeckers*. What is the nature of their food? Are they friends or foes?

(*g*) How do Woodpeckers *drum?* What is the difference between the *tap* and the *drum?*

(*h*) How does the woodpecker use its tail in climbing? What is the arrangement of its toes?

(*i*) Describe the *Flicker*. Compare it with the other woodpeckers.

(*j*) Compare the male and female flickers and other woodpeckers as to color and markings.

(*k*) Watch a flicker feeding its young.

(*l*) What woodpeckers are winter birds? Find out when the others come and go.

## LIV. The Robin.

1. *Movements.* Describe the movement of the robin on the ground; and its manner of flight. Compare its flight with that of the Swallow, Song Sparrow, Meadow Lark, Red-headed Woodpecker. What are the characteristic movements of the Robin?

2. *Song and Call.* How many different calls can you detect? Imitate them. What is the apparent meaning of each call? At what seasons does the Robin sing? Does it sing at night? When raining?

3. *Color and Shape.* Are the males and females of the same color and size? Are the young of the same color as the old? What parts are dark? Pure black? White? Red? When does the Robin moult? Draw the robin.

4. *Nest and Eggs.* Determine the time occupied in building the nest and in brooding. When does it begin to make a nest ? Where does it build? Of what is the nest built? Is the nest used more than once? How often each season does the Robin brood? How long before the first egg is hatched? What is the number, shape, and color of the eggs? When does the mother bird leave the nest to feed?

5. *Food.* What is the most common food of the Robin? When is the Robin not beneficial? What is the food of the young? Compare the food of the Robin with that of the Bluebird, Wood Thrush, Hairy Woodpecker, etc.

6. *General Questions.* Where do the Robins pass the winter? What is the exact date of leaving your locality? And return? Do the same Robins return every spring to the same localities? Compare the nesting habits of the Robin with those of the other members of the

Thrush family. Do both males and females look after the nest and help to feed the young?

## LV. Bird Identification Blank.

*Locality* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ......
*Date* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... .........
*Haunt* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ......
*Length (tip of bill to end of tail)* ...... ...... ...... ...... ...... .........
*Size and shape of bill* ...... ...... ...... ...... ...... ...... ...... .........
*Length and shape of tail* ...... ...... ...... ...... ... ......... ...... ......

COLOR—

*Forehead* ...... ...... ...... ...... ...... ...... ...... ...... .........
*Crown* ...... ...... ...... ...... ...... ...... ...... ...... ...... .........
*Cheeks* ...... ...... ...... ...... ...... ...... ...... ...... ...... .........
*Nape* ...... ...... ...... ...... ...... ...... ...... ...... ...... .........
*Back* ...... ...... ...... ...... ...... ...... ...... ...... ...... .........
*Rump* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...
*Upper-tail coverts* ...... ...... ...... ...... ...... ...... ... ...... ......
*Tail*...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ......
*Wings* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...
*Throat* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...
*Breast* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...
*Abdomen* ...... ...... ...... ...... ...... ...... ...... ...... ...... ......

*Voice* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...
*Movements* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...
*Nest* ......... ...... ...... ...... ...... ...... ...... ...... ...... ...... ......
*Food* ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...

Then use the *keys* in Merriam, Hoffman & Walter for identification.

## LVI. Red Squirrels.

1. Why are red squirrels not desirable animals to have about home?

2. Find a nest. Has it the same nest for both summer and winter? Of what is it composed ?

3. What is the food of red squirrels ? Watch a squirrel eating. Sketch.

4. Show clearly how the squirrel is well adapted to a life among trees.

5. Examine the mouth of a squirrel, and show how the teeth are well adapted for opening nuts and grinding hard seeds.

6. What enemies have squirrels ? Watch a squirrel in flight. Determine how its passes from tree to tree.

7. Study the calls of the squirrel.

8. What are the uses of the tail ?

9. How does the chipmunk differ in appearance from the red squirrel? Sketch.

10. Compare the habits of the squirrels.

### LVII. Water, Steam, and Ice.

1. Determine the physical properties of water, such as color, taste, shape, surface, and cohesion, by simple experiments. In what respects does water differ from steam or ice?

2. Describe the effects of heat on water in a glass flask. What is the cause of "singing" just before boiling? Is steam visible? What is a cloud?

3. What happens when a jet of steam strikes a cold surface?

4. What is evaporation? Why is evaporation more rapid some days than others?

5. Why do wet clothes dry more rapidly some days than others?

6. Explain the "sweating of pitchers containing ice-water."

7. Explain the formation of clouds. Why are some clouds white, others black? Why do clouds move?

9. How is rain formed? When clouds rapidly disappear what is the probable reason?

10. Determine the conditions of formation of ice and snow.

11. Examine snow-flakes and observe their structure.

12. How could you show that water expands on being heated? That water expands on freezing?

13. What is a thermometer? What is its use?

14. Show that heat is required to melt ice.

### LVIII. The Air.

1. What are the proofs for the existence of air? Make experiments.

2. Show that air exerts pressure, is elastic, has weight, expands when warmed, and contracts when cooled (use an air-thermometer to show expansion and contraction).

3. Air is a gas. Name other gases which are also colorless and odorless.

4. Make some carbonic-acid gas and determine its properties. How do its properties differ from those of air?

5. Why water rises when the piston is drawn up in a "squirt-gun" or syringe.

6. The barometer. Why is mercury used? What is the use of the barometer?

7. Winds: Their cause, direction, importance, kinds.

### LIX. The Lamp or Candle Flame.

1. What part of the flame gives forth most light ? Sketch the flame.

2. By lowering a sheet of white paper upon the flame find at what part the flame is hottest by observing the areas scorched.

3. What is the use of the wick ? Is it consumed ?

4. Determine all that happens when a fine wire gauze is lowered upon a flame. Explain the phenomena.

5. Have you evidence that there is a gradual conversion of the solid tallow into a liquid, then into gas, before it burns?

6. How can you show that free Carbon is present in the luminous part of the flame? Explain the "smoking" of a lamp or gas jet.

7. How can you show that without air a candle will not burn ? Account for the presence of the holes in the base of a lamp-burner.

8. Show that carbon dioxide gas is formed when a candle burns.

### LX. A Snow Storm.

1. What causes snow ?
2. At what temperature do snow crystals form ?
3. How do the clouds appear before a snow storm ?
4. What is the temperature of the air before the storm?
5. What is the direction of the wind before the storm ?
6. Does the storm come in the same direction as the wind ?
7. What are the conditions of the wind and temperature when the snow crystals are most perfect in form ?
8. What are these conditions when the snow crystals are matted together in great flakes ?
9. What are these conditions when the snow crystals appear sharp and needle-like?
10. Are the snow crystals of the same storm similar in structure and decoration ?
11. What is the difference in structure between a snowflake and a hailstone?
12. What is sleet ?
13. What is the difference between hoar frost and snow ?
14. Does the temperature rise or fall during a snow storm ?
15. Is it colder or warmer after a storm has passed than it was before it began ?
16. What are the conditions of weather which cause a blizzard?
17. Why does a covering of snow prevent the ground from freezing so severely as it would if bare ?

18. Why is snow a bad conductor of heat ?

19. Pack snow in a quart cup until it is full and then let it melt, and tell how full the cup is of water. What do you infer from this?

20. Have you ever observed the grass to be green beneath snow drifts ?

21. Does snow evaporate as well as melt?

22. How does the snow benefit the farmer and the fruit-grower ?

23. Do the snow storms in your locality come from one general direction all winter? (Cornell Home Nature-Study Leaflet).

## LXI. A Thunder Storm.

The pupils should have access to a thermometer and a barometer, and should learn to read and to interpret the readings.

1. What is the state of the air before a thunderstorm?

2. How could you tell there was a great deal of water-vapor in the air at such a time ?

3. Is the air near the ground colder or warmer than the upper air ? How can you tell ?

4. Are there currents of air ? In what direction ? Why ?

5. Why should great banks of cumulus clouds appear ?

6. Observe carefully the growth of this bank of clouds. Why is its base flat ?

7. Why does rain fall ? What is the function of the " dust " particles ?

8. Why do hailstones often fall in a thunder storm?

9. Account if you can for the lightning and thunder. At what time of the day do thunder storms usually occur ?

10. Describe the passing away of the storm.

## LXII. The Work of Rain.

Visit (1) a loose or sandy bank, and (2) a level field, after a rain storm, and study the work of the rain.

1. Ascertain where the deep furrows are made.

2. What becomes of the constituents of the bank and field when carried away ?

3. What kinds of material are carried farthest by the water ?

4. Examine a rain-pool, and, after it has dried, account for the position of the deposits.

5. Find a delta; study its structure in detail.

## LXIII. The Work of Streams.

Determine the following points after a visit to a stream (1) before rain; (2) after rain:

1. Where is the stream most rapid? In shallow or deep places?

2. The carrying power of water of different velocities.

3. The position of *bars* and other obstructions in the channel, and the causes.

4. The cause of variation in width of stream.

5. When banks are worn away, where are the materials deposited?

6. What gives the general direction to the stream?

7. Account for the depth of water at bends, and the causes of bends and windings.

8. When do streams tend to straighten their courses?

9. Account for the difference between a gorge and a wide valley.

10. Account for the presence or absence of water-falls.

## LXIV. Soils.

Classifications of Soils:

1. *Loam,* composed of equal parts of sand and clay, with some organic matter.

2. *Sandy Loam,* in which there is more sand than clay.

3. *Clay Loam,* in which there is more clay than sand.

4. *Clay Soil,* composed largely of clay.

5. *Sandy Soil*, composed largely of sand.

6. *Gravelly Soil*, containing many pebbles and small stones.

7. *Humus or Organic Soil,* composed largely of decaying organic matter, such as the black soil of swamps, decayed leaves, wood, earth, etc.

Soils are said to be *light* when sand is predominant, and as *heavy* when clay is in excess. The terms Light and Heavy do not refer to the actual weight of the soil, but to the stickiness and the amount of resistance it offers to tools of cultivation.

Properties of Soils:

1. *Physical Properties*, the more important being,
   - (*a*) Power to absorb and hold heat.
   - (*b*) Power to absorb and hold moisture.
   - (*c*) Power to absorb and hold gas.
   - (*d*) Power to absorb and hold plant food.

2. *Chemical Properties*, relating to the chemical composition of the soil, and the chemical changes which take place in the soil.

3. *Biological Properties*, relating to the life in the soil.

(*a*) The microscopic plants, Bacteria, which oxidize the materials of the soil.

(*b*) Those organisms which break up or decompose the soil compounds.

(*c*) Those organisms which enrich the soil.

(1) Collect samples of the different kinds of soils mentioned above, and label the samples in bottes or vials.

(2.) Make a map of your farm.

(3.) Locate the different soils on this farm on the map, giving a definite color to each variety of soil.

(4.) To what extent has erosion agents, such as rains, running water, etc., modified the surface of the farm since Glacial Times?

(5.) Collect or find samples of alluvial soils, residual soils.

(6.) Determine the depth of the *humus soil* in the woods; in land which has borne but one crop.

(7.) At what depth do you find the subsoil in the different fields.

(8.) To what extent are the crops of the farm influenced by differences in the soil? Are some fields better adapted for certain crops than other fields.

(9.) Determine the physical properties of the various soils collected as per question I.

### LXV. Experiments with Soils.

1. The power of loose soils to retain moisture.
2. The power of compact soils to retain moisture.
3. The rate of rise of capillary water in soils.
4. Relation of texture of soils to germination.
5. Texture of different soils after rain.
6. The conservation of moisture, value of mulches.
7. Mechanical analysis of soils.

### LXVI. School Gardens.

For each student: one hoe, one garden rake, one garden line, four corner pegs, two dozen 6-inch plant labels, and a note-book.

1. Special Topics for discussion and investigation:

(*a*) The site and aspect of the garden.

(*b*) The soil and its improvement by spade-work, draining and manuring.

(*c*) The build of a plant.

(*d*) What a plant is made of.

(*e*) How plants are nourished.

(*f*) Sap and its movements.

(*g*) Conditions of healthy growth.

(*h*) Germination, growth, flowering, fruiting, and seeding.

(*i*) Annuals, biennials, and perennials.

(*j*) Evergreen and deciduous trees and shubs.

(*k*) The dependence of plants upon insects.

(*l*) The effect of choosing for seed the larger or smaller samples.

(*m*) The effect of early and late springs on vegetation.

2. Some Arithmetic questions:

(*a*) The garden account.

(*b*) The number of plants to fill a given space.

(*c*) The comparative cost of two plots treated differently.

(*d*) The calculation of the perecentage of sound seeds in a sample for a germination test.

(*e*) The calculation of the loss by insects, by fungi; and the gains by beneficial birds, frogs, and insects.

3. Some Geometry problems:

(*a*) The laying out of the plots by various forms.

(*b*) The construction of plants to scale.

(*c*) The slope of the garden.

4. Drawing in connection with School Gardens:

(*a*) The making of diagrams to illustrate important facts of plant and insect life.

(*b*) Drawings from nature of beautiful flowers and leaves.

5. What to plant:

(*a*) Planting of bulbs, etc., in fall.

(*b*) Planting of vegetable seeds in spring.

(*c*) Planting of flower seeds in spring.

(*d*) Planting of seedling trees.

6. *Preparation of the Bulb Bed.* Select sandy soil, if possible, if clay soil secure drainage; throw out six inches of the soil; work in two inches of manure in the bed; throw back half of top soil and plant bulbs; cover with remaining top soil. Cover with straw or leaves to a depth of six inches when crust is frozen. Remove cover gradually in April.

7. *The Planting of Bulbs for Spring.*

Hyacinths—6 inches apart.
Tulips—4 or 5 inches apart.

Narcissus—3 inches apart.

Crocusses and Snowdrops—touching one another, and from 3 to 4 inches deep.

8. *Winter Flowering Bulbs.* Oriental Narcissus and Freesia.

Place Oriental Narcissus bulb in a large bowl, in the bottom of which are some stones; fill with water and place the bowl in a warm, light place.

Place four or five freesia bulbs in a pot containing light soil; put in a warm, light place, and keep them moist.

9. Make a *Calendar* of dates of planting the various vegetable seeds when there is a succession of vegetables through the season.

10. Make a diagram showing the succession of vegetables.

11. What vegetables may be planted in fall?

12. What planting of perennial flowering plants should be done in the fall?

## LXVII. Rocks and Stones.

1. *In a Gravel Pit.*

(*a*) Assort the stones collected with respect to (1) shape, (2) material composing them.

(*b*) What kind of stone is most abundant? Why are so many kinds found together?

(*c*) Are any of the stones like the rock found in the rocks underneath, or quarries, in the neighborhood?

(*d*) Account for the presence of so many stones away from a stream; also for the sand layers.

(*e*) What agent, or agents, has given shape to the stones?

(*f*) What evidences that the stones have been placed in their present position by water? Any evidences that water had nothing to do with it?

(*g*) Note the direction of the gravel ridge. Do other gravel ridges of district run in the same direction?

(*h*) What evidence that the ridge has been formed for some time?

(*i*) Compare the surface of stone with that of freshly broken stone. Account for the difference.

(*j*) Account for the coloring of some stones and beds.

2. *On the Surface of the Ground.*

(*a*) Visit a stone-pile in a field. Collect as many kinds as you can.

(*b*) What proportion is rounded? What are the names of the kinds of rocks collected?

(*c*) Compare the surface of exposed and freshly broken rocks.

(*d*) What is the nature of the soil on which the rocks were found?

(*e*) Account for the presence of such stones (boulders).

(*f*) Are they strewn evenly over the field? over the district?

(*g*) Find specimens of rocks which are badly decomposed, and observe the nature of the residue.

3. *In a Quarry or River-bank.*

(*a*) What is the composition of the rock?

(*b*) Are the rocks in layers? Are they horizontal?

(*c*) Are the layers (strata) composed of the same material? Are they of equal thickness? Try and explain the variations.

(*d*) Measure the Dip, and strike off the rocks.

(*e*) Are their fossils in the rocks?

(*f*) Examine the soft material lying above the rock, and determine how it has been formed.

### LXVIII. The Surface Features of the District.

(From Jackman's Nature Study.)

1. In looking over the country about you, can you tell what has been the most important agent in its formation?

2. Is the same force still at work? Is it working rapidly or slowly?

3. What other forces have left their impress upon the country? Are they still acting?

4. Are there any evidences as to whether these forces ever worked more rapidly or more powerfully than now?

5. Can you find any place where the land is being torn down? What is doing it? What becomes of the material when torn away?

6. Are there any forces which oppose the tearing away?

### LXIX. The Heavens at Night.

1. Determine the position of the *Great Bear, Cassiopeia, Vega,* and *Capella*, with reference to the North Star or *Polaris*. Observe their apparent rotation about Polaris once every day.

2. Determine the time of rotation of the earth on its axis. Describe the method.

3. Locate the position of: Taurus (Bull), Perseus, Orion, Leo, Virgo, Aries (Ram), Pegasus, and Aquarius,—Northern Crown, Northern Cross, Scorpio, with reference to the Great Bear? Explain why we cannot see Orion and Leo in a summer evening. If possible, locate the position of the constellations in early evening, at midnight, and in early morning, say 3.30. Note the changes.

4. Why does the Great Bear appear in early evening high up in May and low down in the Northern sky in October?

5. Determine roughly the *right ascension* and *declination* of the stars: Arcturus, Aldebaran, Sirius, Rigel, Atair, Antares, Capella, Vega, Castor, Procyon. To what constellation does each belong?

6. What constellations lie in the Milky Way? In the Ecliptic? What constellations are always above the horizon, and therefore visible at night?

7. Determine the real direction the moon travels in the sky with regard to the earth. How many degrees does it travel in 24 hours? How many in 28 days?

8. Locate the planets whenever they become visible and follow their courses. What is an evening star?

(Procure Whittaker's *Planisphere*, and Phillip's *Orrery*, and Whittaker's *Almanac*, and study carefully the movements of constellations and Planets).

## LXX. Weather and Weather Observations..

*Requisites*: Daily weather map issued from Meteorological Observatory, Toronto, thermometer, barometer, wind-gauge, and, if possible, the maximum and minimum thermometer and hygrometer.

1. Study the daily weather-map and understand the construction of *isotherms* and *isobars*. The meaning of a number of concentric isobars.

2. Point out clearly *low pressure* and *high pressure* areas and their significance.

3. By a study of several consecutive weather-maps ascertain if the low pressure area moves. What direction? Why? How far each day? Does it follow a certain route?

4. Does a high pressure area move? In what direction? Why?

5. Examine several maps and determine the direction and velocity of the wind near a low pressure area; near a high pressure area. Can you make a general rule?

6. What effect will the direction have on the temperature of the area? Explain.

Discover if the direction of the wind determines locality of cloudiness and rain. Explain.

7. Make daily observations of the readings of the instruments, and make a record of such observations in a special note-book.

A schedule such as the following is recommended:

METEOROLOGICAL RECORD FOR ............ 190

Time of observation ............

By ............

| Date | Temperature | Barometer | Direct. of wind | Rainfall | Cloudiness | Humidity | Frost or dew | Sun sets | Moon rises | Moon's Phase |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |

8. Make weekly, monthly, or yearly *graphs* of the temperature, barometer, rainfall, etc.

## LXXI. Some Farm Operations.

1. What system of rotation is practised on your farm? What is the advantage of a rotation? Why is it necessary?

2. What is a soiling crop? What plants may be used for soiling crops? What are the advantages of each?

3. What is a cover crop? What plants may be used for cover crops?

4. Explain the construction of a silo. What is its use? How and when is it filled? How is the silage used as feed?

5. What is the order of *seeding* in the spring? Why? What advantage in fall plowing?

6. How is the land *prepared* for seeding? The reason for the thorough cultivation? What implements are used?

7. What are the uses of drains? How are they made? When may the drains be made deep? When shallow?

8. What is hay? How cured and why? What plants are grown for hay? What machinery is used in haying?

9. When are grain crops ready to harvest? Why leave the sheaves out in *stooks* for a few days? Describe the operation of threshing. What machinery is used?

10. What advantages arise from cultivating stubble land after harvest? How to rid a badly infested field with weeds?

11. When are clover and timothy sown? Why at that time and with that crop? Why should clean seed only be used? What is meant by *seeding down*?

12. What are the uses of root crops? When and how is the land prepared for corn, for mangels, for turnips? How is each crop harvested?

13. *What is a balanced ration?* Is the ration the same for different animals?

14. Make plans for a stable suited to a 100-acre farm,—general farming.

15. What are the daily operations on your farm in winter?

16. Why should manure be cared for? When should it be applied to the land? What constituent taken from the soil is the most costly to replace? How is it replaced?

17. When and how should the orchard be sprayed? Describe the operations of preparing the solutions and applying them. Why should there be cleanliness about an orchard?

18. When should pruning be done? Why should it be done carefully? Should an orchard be cultivated and fertilized? When?

19. Describe the process of harvesting, of shipping, and of storing fruit.

20. How should milk be cared for? What need for cleanliness? For cooling? For kindness to milch cows? What are the distinguishing characters of a good milch cow? What breeds are the best milk producing breeds? How many pounds of milk should a profitable dairy cow give per year?

# Some of the Most Helpful Books in Nature Study.

## I. PLANTS.

| | | | |
|---|---|---|---|
| 1. | Lessons with Plants | Bailey ; MacMillan & Co. | $1.25 |
| 2. | Plants | Coulter ; Appleton & Co. | 1.80 |
| 3. | First Studies in Plant Life | Atkinson ; Ginn & Co. | .75 |
| 4. | Elementary Botany | Bailey ; MacMillan & Co. | 1.00 |
| 5. | Agricultural Botany | Percival ; Holt & Co. | 1.75 |
| 6. | Reader and Outlines in Botany | Newell, 4 vols.; Ginn & Co. | 1.70 |
| 7. | Seed Dispersal | Beal ; Ginn & Co. | .40 |
| 8. | Sylvan Ontario | Muldrew ; Briggs | .50 |
| 9. | How to Make School Gardens | Hemenway ; Doubleday, Page & Co | 1.00 |

## II. ANIMALS.

| | | | |
|---|---|---|---|
| 1. | Animal Life | Jordan & Kellogg ; Appleton & Co | 1.10 |
| 2. | Animal Forms | Jordan & Heath; Appleton & Co. | 1.20 |
| 3. | Story of the Fishes | Basket ; Appleton & Co. | .65 |
| 4. | Wild Neighbors | Ingersoll ; Harper & Bros | 1.50 |
| 5. | Squirrels and Other Fur Bearers | Burroughs ; Houghton, Mifflin & Co | 1.20 |
| 6. | Birds of Village and Field | Merriam ; Houghton, Mifflin & Co | 2.00 |
| 7. | Bird Life | Chapman ; Appleton & Co. | 3.00 |
| 8. | Story of the Birds | Basket ; Appleton & Co | .65 |
| 9. | Manual for the Study of Insects | Comstock ; Comstock Publ. Co., Ithaca, N. Y. | 3.75 |
| 10. | Insect Life | Comstock ; Appleton & Co. | 1.75 |
| 11. | Stories of Insect Life | Weed ; Ginn & Co. | .35 |
| 12. | The Bee People | Morley ; McClurg & Co. | 1.25 |
| 13. | The Butterfly Book | Holland ; Doubleday, Page & Co. | 3.00 |
| 14. | The Moth Book | Holland ; Doubleday, Page & Co. | 4.00 |
| 15. | The Insect Book | Howard ; Doubleday, Page & Co. | 3.00 |
| 16. | How to Name the Butterflies | Comstock ; Appleton & Co. | 2.50 |
| 17. | The Birds of New Engiand | Hoffman ; Houghton, Mifflin & Co. | 1.60 |
| 18. | Wild Birds in City Parks | Walter ; Mumford, Chicago | .50 |

### III. PHYSICAL GEOGRAPHY AND GEOLOGY.

| | | | |
|---|---|---|---|
| 1. | Elementary Geology | Tarr ; MacMillan & Co. | $1.40 |
| 2. | Elementary Physical Geography | Gilbert & Brigham ; Appleton & Co | 1.40 |
| 3. | Elementary Geology | Brigham ; Appleton & Co. | 1.40 |
| 4. | Physical Geography | Dryer ; American Book Co. | 1.25 |
| 5. | H. S. Geography | Chase ; Can. Pub. Co. | 1.00 |
| 6. | Modern Geography | Morang | .75 |
| 7. | Child and Nature | Frye ; Ginn & Co | .80 |

### IV. CHEMISTRY AND PHYSICS.

| | | | |
|---|---|---|---|
| 1. | Simple Experiments for the Schoolroom | Woodhull ; Kellogg & Co., N.Y. | .50 |
| 2. | Elementary Physics and Chemistry | Gregory & Simmons ; MacMillan & Co | .50 |

### V. NATURE STUDY.

| | | | |
|---|---|---|---|
| 1. | Nature Study and the Child | Scott ; D. C. Heath | 1.50 |
| 2. | Nature Study and Life | Hodge ; Ginn & Co. | 1.50 |
| 3. | Guide to Nature Study | Crawford ; Copp, Clark Co. | .90 |
| 4. | Modern Nature Study | Silcox & Stevenson ; Morang | 1.00 |
| 5. | Nature Study for Common Schools | Jackman ; Holt & Co. | 1.20 |
| 6. | The Nature Study Idea | Bailey ; Doubleday, Page & Co. | 1.00 |
| 7. | Public School Nature Study | Crawford, and others ; Copp, Clark Co. | .50 |

### VI. NATURE READERS.

| | | |
|---|---|---|
| Friends Worth Knowing | Ingersoll ; Harper & Bros. | 1.00 |
| Ways of Wood Folk | W. J. Long ; Ginn & Co. | .65 |
| Wilderness Ways | W. J. Long ; Ginn & Co. | .65 |
| Wild Animals I Have Known | Seton-Thompson ; Scribner | 2.00 |
| Lives of the Hunted | Seton-Thompson ; Scribner | 2.00 |
| Nature Pictures | American Poets ; MacMillan & Co. | 1.25 |
| Poetry of the Seasons | Lovejoy ; Silver, Burdett & Co. | .60 |
| Nature in Verse | Lovejoy ; Silver, Burdett & Co. | .60 |
| Little Wanderers | Morley ; Ginn & Co. | .35 |
| Flowers and Their Friends | Morley ; Ginn & Co. | .60 |

| | | |
|---|---|---|
| Nature Study or Stories in Agriculture | Staff O. A. C. | |
| Nature Study Bulletins and Leaflets (Cornell) | Humphrey, Geneva | $1.00 |
| Songs of Nature | Burroughs ; McClure, Phillip & Co. | 1.00 |
| Nature Biographies | Weed ; Doubleday, Page & Co. | |
| Flashlights from Nature | Grant-Allen ; Briggs | |
| Nature's Garden | Blanchan; Doubleday, Page & Co. | |
| The Study of Animal Life | Thomson ; Murray | |
| Wild Life Near Home | Sharp ; The Century Co | |
| A Hermit's Wild Friends | Walton ; Dana, Estes & Co. | 1.50 |
| Wake Robin, Birds and Poets, Locusts and Wild Honey, Winter Sunshine | Burroughs ; D. Douglas | 1.00 |

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Published by the Ontario Department of Agriculture, Toronto.

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| 107 | May | 1898 | Dairy Bulletin (out of print, see No. 114) | Dairy School. |
| 108 | Aug. | 1898 | Experiments with Winter Wheat | C. A. Zavitz. |
| 109 | Sept. | 1898 | Farmyard Manure | G. E. Day. |
| 110 | Jan. | 1900 | Experiments in Feeding Live Stock (out of print) | G. E. Day. |
| 111 | Dec. | 1900 | Lucerne or Alfalfa | R. Harcourt. |
| 112 | Dec. | 1900 | Foul Brood of Bees | F. C. Harrison. |
| 113 | Mar. | 1901 | Sugar Beet Experiments in Ontario | A. E. Shuttleworth |
| 114 | May | 1901 | Dairy Bulletin | Dairy School. |
| 115 | July | 1901 | Comparative Values of Ontario Wheat for Breadmaking Purposes | R. Harcourt. |
| | | | Notes on Varieties of Winter Wheat | C. A. Zavitz. |
| 116 | Aug. | 1901 | The Hessian Fly in Ontario | Wm. Lochhead. |
| 117 | Jan. | 1902 | Pasteurization of Milk for Butter-making | H. H. Dean. F. C. Harrison. |
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| 125 | Dec. | 1902 | Roup (A Disease of Poultry) | F. C. Harrison. H. Streit. |
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ONTARIO AGRICULTURAL COLLEGE

BULLETIN 143

# Dairy School Bulletin

By

THE STAFF OF THE DAIRY SCHOOL, GUELPH.

PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE
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**Bulletin 143.** **June, 1905.**

Ontario Agricultural College and Experimental Farm.

# DAIRY SCHOOL BULLETIN.



## INTRODUCTION.

By H. H. Dean, B.S.A., Professor of Dairy Husbandry.

The bulletins which have been prepared by the members of the Dairy School Staff at the Ontario Agricultural College appear to have been appreciated, and there is a great demand for them. We trust that this one will prove as helpful as those published in the past. The aim is to make the bulletin popular and practical. In some departments there is not much change from the last. Our system of buttermaking has undergone more changes than any other branch of dairy work, and there is yet great room for improvement. We hope that the bulletin will prove useful for the man who cares for and milks the cows, and also to the manufacturers of cheese and butter in the factory and on the farm.

Dairy Farmer. Many dairy farmers grow discouraged during the season of low prices and sell their cows. This is a great mistake. No branch of agriculture is so stable and so remunerative as dairying during a series of years. A year of low prices is usually followed by one of high prices. The cow is undoubtedly the best paying animal on the farm if she is fed and handled properly. However, in order to make a cow pay it is necessary that her owner shall possess certain qualifications. The most important of all is that he shall have a real liking for the cows, not only because of the money which they earn, but he must like them simply because they are cows. A person who really likes cows will take pleasure in feeding and looking after them. To him it is not drudgery. This person will always treat cows kindly and considerately. There will always be a bond of sympathy between the owner and the cow. Each will strive to do the best possible for the other.

This owner of cows must study their habits, likes, and dislikes. He must feed them liberally and make them as comfortable as possible. Unless he or she is prepared to be a student of cows, success is not probable. To the dairy farmer we should say, know your cows *individually*. This can be best done by weighing the milk from each cow daily, once a week, on two consecutive days each month, or even once a month. Samples for testing should also be taken on the day or days for weighing in order to know the percentage of fat in the milk. This, together with a close observation of the feed consumed by a cow, will enable a dairy farmer to determine whether or not his cows are making a profit. It will also enable him to intelligently weed the poorer cows.

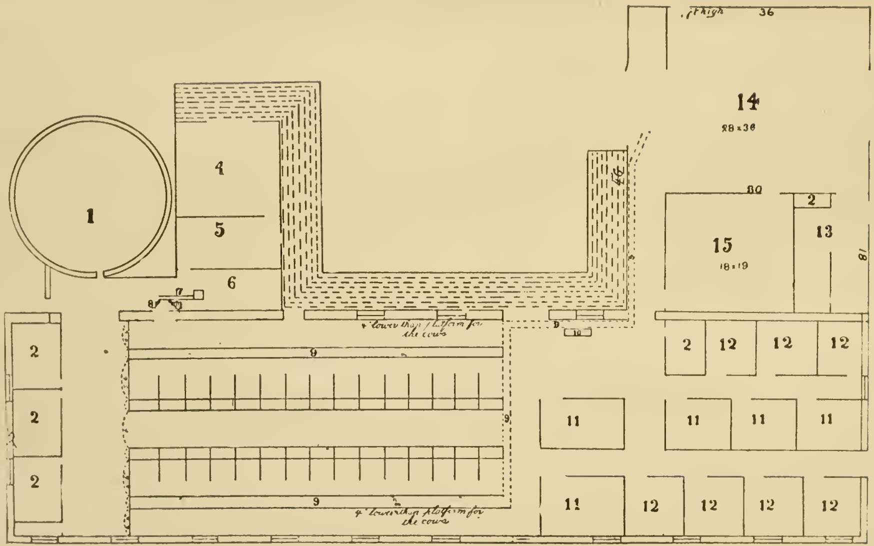
DAIRY COWS may be purchased or they may be bred. Frequently good cows may be bought at reasonable prices, but generally speaking they must be reared by the dairy farmer. For the dairyman, who cannot afford to keep pure-bred cows, it is desirable to select grade or native cows and breed these to a pure-bred male belonging to one of the dairy breeds. Great attention should be paid to the sire, as milking quality in the female depends more on the sire than on the dam. Dairy farmers do not sufficiently realize the importance of this point. Excellent dairy cows may be secured at small cost by using a dairy sire belonging to a dairy breed and a dairy family. In this way a herd of ordinary or inferior breeding may soon be transformed into a herd of good milkers. The fundamental mistake made by many breeders of dairy cows is in the use of inferior or what are commonly called "scrub" sires. The patrons of every cheese factory and creamery ought to have the use of a pure-bred bull at nominal cost. It would pay the factories to adopt some co-operative plan to secure this result.

Calves and heifers for the dairy should be kept in a thrifty condition but not too fat. They should commence milking when about two and one-half years old. At the end of the second lactation period and during all future years they should produce not less than 6,000 lbs. milk or 250 lbs. butter yearly. This may be taken as a minimum standard of production for profitable dairy cows. Stated another way, they should earn from $25 to $100 per cow each year, above the cost of feed.

DAIRY STABLE. The chief requirements in a dairy stable are that it shall be light, clean, and healthful. The first is got by having plenty of clean windows, the second by having cement floors, with stalls of proper length and a gutter or drop behind the cows, and the last by having the stable well ventilated, and whitewashed at least once a year. Mangers are not necessary in a modern cow stable.

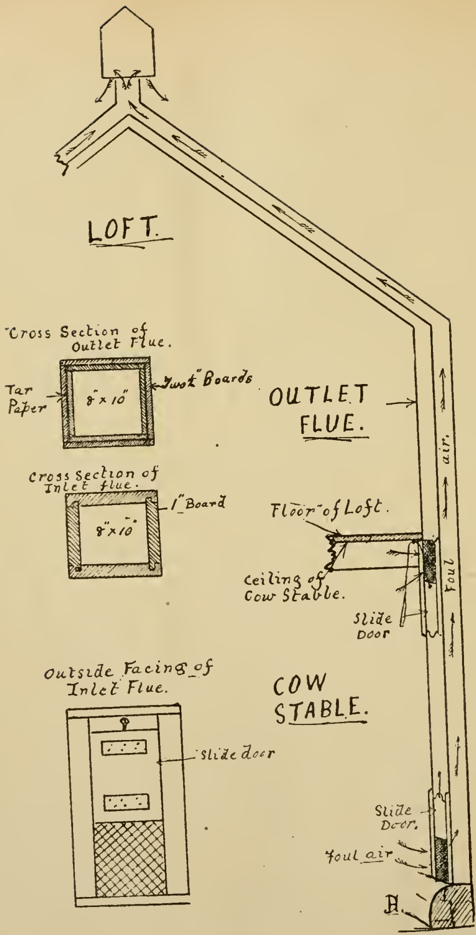
Conditions vary so much on different farms that it is difficult to give a plan suitable for all farms. The accompanying illustrations will show the arrangements in the dairy stable of the College and on the whole it is quite satisfactory. The feed bins are located at one end of the stable and the box stalls, eleven in number, at the other. There is room for thirty cows to be tied up. A large room above the stable holds the hay and straw. This is not the most sanitary arrangement, but it is convenient.

The King system of ventilating is the one adopted in the dairy stable and it is quite satisfactory. There are six inlets and eight outlets. The cost of putting in the ventilation was $136, including the cost of galvanized iron ventilators, of which there are four connected with the eight outlets from the stable.

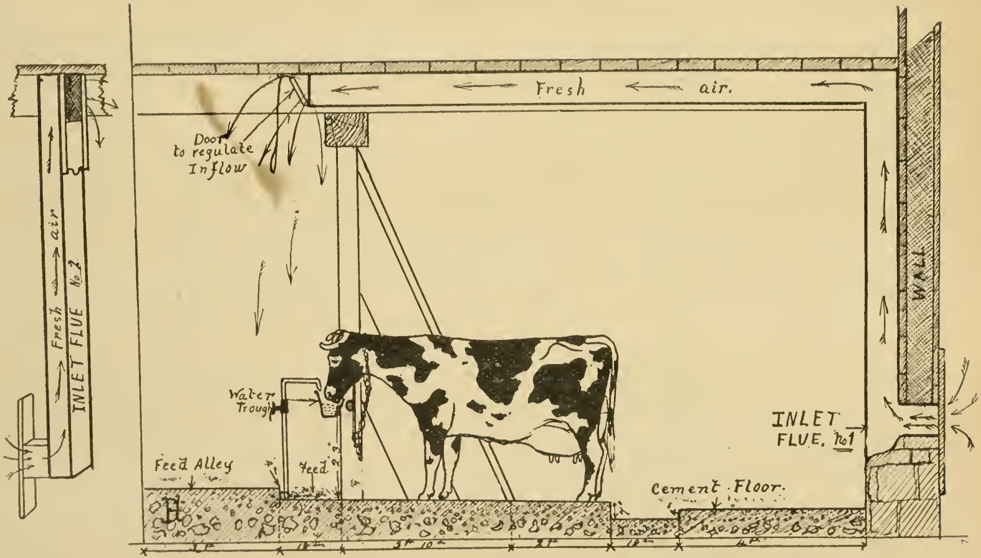



Ground plan of Dairy Barn, O.A.C. Guelph.

1, silo; 2, feed bins; 4, 5, 6 and 15, storage rooms; 9, gutter behind cows; 11 and 12, box stalls; 13, horse stalls; 14, manure shed.



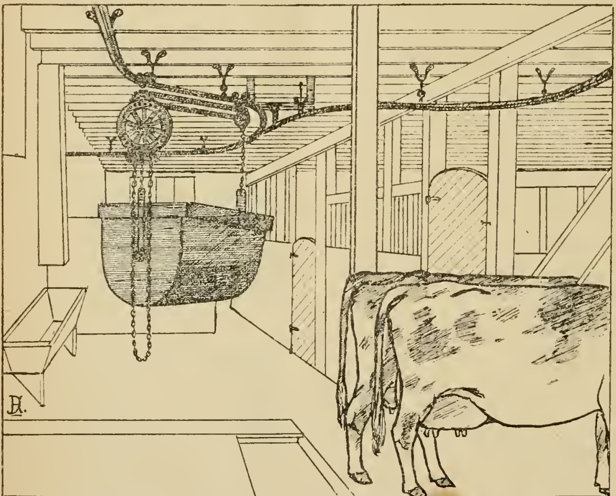

Plan showing outlet for foul air. There are eight of these in the stable—four on each side. One from each side enters a ventilator at roof.




Cross section of stable showing one-half the feeding alley, place for feeding, water trough, stall, gutter, passage behind the cows and inlets for fresh air. There are six of these, one-half of which open at the ceiling behind the cows and one-half in the centre of the stable.

FEEDING THE COW. The natural food of the cow is grass and nothing is equal to good pasture for cows. In order to secure good pasture on cultivated land it is advisable to give more attention to the method of, and mixture used for, seeding. A very good combination of grasses and clovers, where a rotation of crops is practised, is the following: 4 lbs. timothy, 5 lbs. orchard grass, 7 lbs. red clover, and 2 lbs. alsike clover, making 18 lbs. of seed per acre.

On fields which may be allowed to remain in pasture for several years, the following mixture is recommended by Prof. Zavitz: 4 lbs. or-



Litter carrier, a great convenience for cleaning Dairy Stable.

chard grass, 4 lbs. meadow fescue, 3 lbs. tall oat-grass, 2 lbs. timothy, 2 lbs. meadow foxtail, 5 lbs. lucerne clover, 2 lbs. alsike, and 2 lbs. white clover, making 24 lbs. of seed per acre.

The same authority recommends for a pasture crop to be used the same year as sown, 51 lbs. oats, 30 lbs. early amber sugar cane, and 7 lbs. red clover—a total of 88 lbs per acre. Cows are very fond of this mixture.

Lucerne or Alfalfa is another crop which dairy farmers should grow. It may be used for green fodder, hay, pasture and for green manure. For hay it should be cut when less than one-third in bloom. It is claimed that a ton of lucerne hay is equal to a ton of bran for milk production. This crop should receive more attention on dairy farms. About 18 lbs.

of seed per acre should be sown on well-drained land in the spring, with or without a crop. It should not be pastured or cut the *first* year. It will give two or three cuttings each year after it is established.

To supplement pastures, green peas and oats, or summer silage are often necessary. These help to maintain the milk flow at a time when the shrinkage would otherwise be considerable. From two to four pounds of meal per cow each day will often pay when the prices of dairy produce are good. This meal may consist of bran and oats, or either of them alone.

For winter feeding, corn silage is undoubtedly the cheapest bulky food at the disposal of dairymen. However, corn silage alone is not sufficient for milking cows. They also need some clover hay, roots, and meal. When dry it pays to feed the cows a moderate amount of meal, as it seems to be a recognized principle that the time to renew a cow is when she is not milking. Too many put their cows on short rations when they are not milking, thus violating the foregoing principle, and the results are not satisfactory. It pays to feed a good cow well when dry. With heavy milkers there is danger of losing the cows through "milk fever," but modern methods of treating this disease make it comparatively harmless, and there is very much less risk now than formerly. Under ordinary conditions the best plan with heavy milkers in high flesh is to not milk the cow any more than is required for the calf for the first two or three days. If the cow is attacked, the "air treatment" is simple and effective.

On the one hand many cow feeders fail to give their animals sufficient to maintain a proper milk flow, while on the other some feeders give more meal than the cows can profitably assimilate. Experiments indicate that cows in full flow of milk should receive about eight pounds of meal daily, together with all the roughage which they can consume. An increase to twelve pounds of meal daily in most cases means an added cost for the milk and butter out of proportion to the increased yield.

The winter feed at the dairy barn of the College is prepared as follows: The hay is cut and mixed with the corn silage and pulped mangels for several hours before feeding. This roughage is given at two feeds, and on it is placed the meal for each cow at the time of feeding. The meal consists of bran, oats and oilmeal. A feed of long hay is usually given once a day in addition to the regular feed.

Our standard ration consists of about

| | |
|---|---|
| 40 lbs. corn silage, | 4 lbs. wheat bran, |
| 10 lbs. clover hay, | 3 lbs. ground oats, |
| 30 lbs. mangels, | 1 lb. oil meal. |

The following table is based on Bulletin 154 from Cornell Station:

DIGESTIVE NUTRIENTS IN ONE POUND OF SOME COMMON FEEDING STUFFS.

| Kind of Food. | Total dry matter. | Pounds of digestible nutrients. | | | Nutritive Ratio. |
|---|---|---|---|---|---|
| | | Protein. | Carbo-hydrates. + (fat x 2 25.) | Total. | |
| Green fodder corn, 1 lb ............ | 0.20 | 0.10 | 0.125 | 0.135 | 1:12.5 |
| " peas and oats, " ............ | 0.16 | 0.018 | 0.076 | 0.094 | 1:4.2 |
| " red clover, " ............ | 0.29 | 0.029 | 0.164 | 0.193 | 1:5.6 |
| " alfalfa clover, " ............ | 0.28 | 0.039 | 0.138 | 0.177 | 1:3.5 |
| Corn silage, " ............ | 0.21 | 0.009 | 0.129 | 0.138 | 1:14.3 |
| Potatoes, " ............ | 0.21 | 0.009 | 0.165 | 0.174 | 1:18.3 |
| Mangels, " ............ | 0.09 | 0.011 | 0.056 | 0.067 | 1:5.1 |
| Sugar beets, " ............ | 0.13 | 0.011 | 0.104 | 0.115 | 1:9.4 |
| Carrots, " ............ | 0.11 | 0.008 | 0.082 | 0.090 | 1:10.3 |
| Turnips, " ............ | 0.10 | 0.010 | 0.077 | 0.087 | 1:7.7 |
| Timothy hay, " ............ | 0.87 | 0.028 | 0.465 | 0.493 | 1:16.6 |
| Mixed hay, " ............ | 0.87 | 0.062 | 0.460 | 0.522 | 1:7.4 |
| Red clover hay, " ............ | 0.85 | 0.068 | 0.396 | 0.464 | 1:5.8 |
| Alfalfa hay, " ............ | 0.92 | 0.110 | 0.423 | 0.533 | 1:3.8 |
| Corn fodder, " ............ | 0.58 | 0.025 | 0.373 | 0.398 | 1:14.9 |
| Corn Stover, " ............ | 0.60 | 0.017 | 0.340 | 0.357 | 1:19.9 |
| Pea Straw, " ............ | 0.86 | 0.043 | 0.341 | 0.384 | 1:7.9 |
| Wheat straw, " ............ | 0.90 | 0.004 | 0.372 | 0.376 | 1:93 |
| Oat straw, " ............ | 0.91 | 0.012 | 0.404 | 0.416 | 1:33.6 |
| Corn, (grain) " ............ | 0.89 | 0.079 | 0.764 | 0.843 | 1:9.7 |
| Wheat, " " ............ | 0.90 | 0.102 | 0.730 | 0.832 | 1:7.2 |
| Rye, " " ............ | 0.88 | 0.099 | 0.700 | 0.499 | 1:7.1 |
| Barley, " " ............ | 0.89 | 0.087 | 0.692 | 0.779 | 1:7.9 |
| Oats, " " ............ | 0.89 | 0.092 | 0.568 | 0.660 | 1:6.2 |
| Buckwheat, " " ............ | 0.87 | 0.077 | 0.533 | 0.610 | 1:6.9 |
| Peas, " " ............ | 0.90 | 0.168 | 0.534 | 0.702 | 1:3.2 |
| Corn and cob meal, " ............ | 0.85 | 0.044 | 0.665 | 0.709 | 1:15.1 |
| Wheat bran, " ............ | 0.88 | 0.122 | 0.453 | 0.575 | 1:3.7 |
| Wheat middlings, " ............ | 0.88 | 0.128 | 0.607 | 0.735 | 1:4.7 |
| Low grade flour, " ............ | 0.88 | 0.082 | 0.647 | 0.729 | 1:7.9 |
| Gluten feed, " ............ | 0.92 | 0.194 | 0.633 | 0.827 | 1:3.3 |
| Gluten meal, " ............ | 0.92 | 0.258 | 0.656 | 0.914 | 1:2.5 |
| Linseed meal (new process) 1 lb...... | 0.90 | 0.282 | 0.464 | 0.746 | 1:1.6 |
| Cotton seed meal, " ...... | 0.92 | 0.372 | 0.444 | 0.816 | 1:1.2 |
| Sugar beet pulp, " ...... | 0.10 | 0.006 | 0.073 | 0.079 | 1:12 |
| Apple pomace, " ...... | 0.233 | 0.011 | 0.164 | 0.175 | 1:14.9 |
| Skim-milk (separator) " ...... | 0.094 | 0.029 | 0.059 | 0.088 | 1:2 |
| Buttermilk, " ...... | 0.10 | 0.039 | 0.065 | 0.104 | 1:1.7 |

To find the pounds of nutrients in any given number of pounds of any feeding-stuff, multiply the pounds by the amount of nutrients in one pound as given in the table.

By referring to the preceding table we find that oui ration contains digestible material as follows:

| Feeding Stuffs. | Total dry matter. | Pounds of digestible nutrients. Protein. | Carbo-hydrates. + (fat x 2.25.) | Total. | Nutritive ratio. |
|---|---|---|---|---|---|
| Corn silage, 40 lbs | 8.40 | 0.360 | 5.160 | 5.520 | |
| Clover hay, 10 " | 8.50 | 0.680 | 3.960 | 4.640 | |
| Mangels, 30 " | 2.70 | 0.330 | 1.680 | 2.010 | |
| Bran, 4 " | 3.52 | 0.488 | 1.812 | 2.300 | |
| Oats, 3 " | 2.67 | 0.276 | 1.704 | 1.980 | |
| Oil-cake, 1 lb | 0.90 | 0.282 | 0.464 | 0.746 | |
| | 26.69 | 2.416 | 14.780 | 17.196 | 1:6.1 |
| Wisconsin standard | 24.5 | 2.20 | 14.900 | 17.100 | 1:6.8 |
| German " | 24.0 | 2.50 | 13.400 | 15.900 | 1:5.4 |

By comparing it with the Wisconsin and German standards, we find that it contains more dry matter than is called for by either, more protein than is asked for in the Wisconsin and less than the German, more carbonaceous material than the German and slightly less than in the Wisconsin, the total digestible material is greater than in the German and about the same as the Wisconsin, while its nutritive ratio is between the two standards, but conforming more nearly to that of Wisconsin.

By using the table as directed any farmer can readily find out the amount of digestible material in his ration and compare it with the standards given. If he finds that the ration is too low in protein or muscle-forming material, then bran, oil-meal, gluten meal, peas or clover hay should be added to the ration, and if necessary some of the more carbonaceous foods such as silage, may be reduced. However, silage, roots, beet pulp, etc., give succulency to the ration which is very important in the economical production of winter milk.

Factory Floods. Substitute, as soon as possible, a cement floor for the wooden floor now in the factory. Grade the ground to a slant of one inch in six feet to a central gutter, then pack the earth firmly and cover with four to six inches of gravel. Pound the gravel solidly. Mix sand and gravel with good cement in the proportion of four or five to one, and lay the grouting about four inces thick on the firm gravel. Finish with one inch of screened sharp sand and the very best brand of cement mixed in the proportion of two to one for the finishing coat. Have the surface smooth so that pools of water will not lie on the floor. The gutter should have a fall of one inch in six to eight feet, to an outlet, and should be made specially solid and even on the side and bottom. Employ a skilled workman to lay the floor, and use none but the very best material.

Place a "bell-trap" at the outlet from the gutter. Use sewer tile with cemented joints in underground drains near the factory, to prevent sewage soaking into the well. The sewage may be disposed of by means of a filter-bed or by the sub-earth system. Do not allow it to accummulate about the factory.

Paying Patrons. Milk is valuable for butter-making in proportion to the fat which it contains, and the pounds of fat delivered in the milk or cream should form the basis of dividing proceeds among patrons of the creameries.

As butter consists of fat, together with about 16 per cent. of water, salt, and curdy matter, there will always be more butter than the fat contained in the milk. This excess of butter over fat constitutes what is known as the "overrun." The "overrun" varies from twelve to sixteen per cent., *i.e.*, 100 lbs. fat in the milk makes from 112 to 116 pounds of butter, and this "overrun" belongs to the patrons, unless otherwise understood. It is unwise for creamery managers to take the "overrun" as part payment for manufacturing.

In cream-collecting creameries the overrun usually varies from twelve to eighteen per cent.

For calculating the yield of butter from fat in the milk, adding one-sixth to the fat is near enough for practical purposes.

Cheese is made largely from two constituents in the milk, viz., fat and casein; therefore, the method of dividing proceeds among the patrons of cheese factories is more complicated than for creameries. Three systems are now in use among factorymen:

1. Paying according to the weight of milk delivered regardless of its quality.

The principle of this plan is that all milk is of equal value per 100 pounds for cheese-making. It rests on a false assumption, is unjust, and it tends to promote dishonesty. Factorymen and honest patrons who complain that some of the milk is skimmed and watered by dishonest patrons, deserve little sympathy, because a remedy is within the reach of all at a very small cost. The milk of all patrons should be tested regularly, and be paid for according to its value for cheese-making.

2. Paying according to the weight of the fat delivered in the milk, the same as at creameries.

The principle of this system is that all milk is valuable for cheese-making in proportion to the fat which it contains. The system is manifestly more just and equitable than the first named, and is to be commended in preference to "pooling" by weight of milk. The chief weakness of the plan is that the yield of cheese is not in direct proportion to the fat contained in the milk; therefore, it gives an undue advantage to the patrons sending milk containing a high percentage of fat.

3. Paying according to the fat and casein in the milk, the casein being represented by the factor 2, added to the percentage of fat.

The principle of this system is that milk, is valuable for cheese-making in proportion to the fat and casein contained in it, and it further assumes that the percentage of fat + 2 represents the available fat and curdy compounds in milk for cheese-making.

The application of the third system is very simple. To illustrate : The tests for fat of patrons' milk are 3.0, 3.5, 3.8 and 4.0. The percentage of fat and casein are 3+2=5.0 ; 3.5+2=5.5 ; 3.8+2=5.8 ; and 4+2=6.0. The pounds of fat and casein are calculated by multiplying the pounds of milk delivered by the percentage of fat and casein. Thus, if the first patron had 1,500 lbs. milk, he would be credited with 1500×5÷100=75 pounds of fat and casein. If the second delivered 2000 pounds milk he would be credited with 2000×5.5÷100, or 110 pounds of fat and casein, and so on with all the others. The value of one pound of fat and casein is ascertained by dividing the net proceeds of the sale of cheese by the total pounds of fat and casein delivered.

The following table gives a summary of the results obtained during five years experiments, in which 250 experiments were made with nearly 200,000 pounds of milk, which contained percentages of fat varying from 2.7 to 5.5.

| Av. p.c. fat in milk. | Lbs. cheese made per 100 lbs. milk. | Lbs. cheese made per 1 lb. fat in milk. | Lbs. cheese made per lb. fat and casein or p.c. fat + 2. | Lbs. loss of fat and casein in whey. | | Percent. lost in curing in four weeks. | Average score. | |
|---|---|---|---|---|---|---|---|---|
| | | | | Per 1,000 lbs. milk. | Per 100 lbs. cured cheese | | Flavor max. 35. | Total max. 100. |
| 2.87 | 8.75 | 3.04 | 1.79 | 2.71 | 3.09 | 4.26 | 30.4 | 89.9 |
| 3.22 | 9.03 | 2.80 | 1.72 | 2.75 | 3.15 | 4.43 | 30.2 | 89.4 |
| 3.83 | 10.02 | 2.61 | 1.71 | 3.34 | 3.21 | 4.10 | 30.8 | 90.3 |
| 4.23 | 10.67 | 2.53 | 1.71 | 3.21 | 3.02 | 4.05 | 31.0 | 90.4 |
| 4.74 | 11.44 | 2.41 | 1.69 | 3.64* | 3.18* | 3.07 | 31.0 | 89.8 |
| 5.21 | 12.13 | 2.32 | 1.68 | 3.40* | 2.80* | 3.53 | 31.5 | 91.6 |

* Fat only. Casein not determined.

Amounts of money (cheese 8c per pound) credited by three systems and also value of cheese.

| Average p. c. fat in milk. | Weight of milk—1,000 lbs. milk. | Weight fat in 1,000 lbs. milk. | Weight of fat and casein in 1,000 lbs. milk, or fat plus 2. | Value cheese made from 1,000 lbs. milk. |
|---|---|---|---|---|
| | $ c. | $ c. | $ c. | $ c. |
| 2.87 | 8 27 | 5 91 | 6 69 | 7 00 |
| 3.22 | 8 27 | 6 63 | 7 18 | 7 22 |
| 3.83 | 8 27 | 7 89 | 8 02 | 8 02 |
| 4.23 | 8 27 | 8 71 | 8 56 | 8 54 |
| 4.74 | 8 27 | 9 76 | 9 27 | 9 15 |
| 5.21 | 8 27 | 10 73 | 9 91 | 9 70 |

"Our five years' experiments prove that this third system comes nearest to the actual value of the cheese produced, though it still places a slight premium on the milk-fat. It encourages the production of good milk, and at the same time does not discourage the majority of patrons who have average milk, and who are apt to envy those whose cows give a small amount of rich milk, and who draw a large share of the proceeds of cheese-sales, when the money is divided on the basis of the fat only." —O. A. C. Report, 1898, p. 52.

Skim Milk and Whey. The value of skim milk for young calves and pigs is much increased by feeding it sweet. The separator creamery should heat all skim milk to 185 degrees, before it leaves the creamery. Sweet skim milk is probably worth 15 to 20 cents per 100 pounds. It has also about the same value for grown pigs when sour, if fed along with meal.

Butter milk has about the same value as sour skim milk, if it does not contain too much water. When selling butter milk in bulk at the creamery, a convenient way is to value it at so much per ton of butter. From three to five dollars per ton of butter is a fair price.

Experiments made at the Ontario Agricultural College showed that 100 pounds of whey were equal to 14 pounds of meal in the production of bacon. Both skim milk and whey had a marked influence in the production of *firm* bacon. When seling whey in bulk at the factory, it is usually valued at from three to six dollars per ton of cheese.

The by-products of cheese-making and buttermaking are valuable factors in adding to the wealth of dairymen through bacon hogs, and the rearing of young cattle for beef and the dairy.

## THE ALKALINE SOLUTION: ITS PREPARATION AND USE.

By R. HARCOURT B.S.A., PROFESSOR OF CHEMISTRY.

CAUSES OF ACIDITY IN MILK. The development of acid is caused by the breaking down of milk sugar into lactic acid, through the influence of certain acid-forming ferments in the milk. But even sweet milk, immediately after it is drawn from the udder, will have an acid reaction with certain indicators. This acidity is not due to lactic acid nor any free acid in the milk, but to the acid nature of the ash constituents, possibly also to the carbonic acid gas it contains, and to the acid nature of the casein. When phenolphthalein is used as an indicator, freshly drawn milk will generally show as much as .10 per cent. of acid and immediately after exposure to the atmosphere, lactic acid germs commence breaking down the milk sugar. At a temperature of 70 degrees to 90 degrees F., these germs multiply at an enormous rate, consequently lactic acid will develop very rapidly in milk during a warm or sultry day or night. Cooling retards the action, but even at a temperaure of 40 degrees to 50 degrees F., they will multiply and considerable lactic acid will be formed. Milk intended for cheese-making should not contain more than .20 per cent. acid when delivered at the factory; whereas it does not usually smell or taste sour until it contains .30 to .35 per cent. A further development of acid will cause the milk to curdle, or, in other words, will produce coagulation of the casein. There is, however, a limit to the development of acid; for, after a certain point, the germs which break down the milk sugar are destroyed by the acid they produce, and there is no further increase in acidity.

In many ways a knowledge of the acid contents of milk or its products is of value. In most cases, a determination of the percentage of acid in the milk when delivered at the factory will indicate the care the milk has received previous to that time. The acid test may be of value in selecting milk best adapted for pasteurization, or for retail trade, or manufacture of high-grade products. At the present time, however, the chief uses made of the alkaline solution in dairy work are to determine the acid in cream intended for churning, and the acid in milk and whey in the various steps in the process of the manufacture of cheese. Both in ripening cream and in cheese-making, acid is developed, and the alkaline solution is now frequently used to measure the amount of acid present and thus control the work.

HOW TO MEASURE THE ACIDITY. The measurement of the amount of acid or alkali in a solution depends upon the fact that it always takes a definite quantity of alkali to neutralize a definite quantity of acid. Thus, for instance, it always takes a definite quantity of caustic soda to neutralize a definite quantity of lactic acid, sulphuric acid, or any other acid. If, then, we know the strength of a given caustic soda solution and measure the amount of it used to render a definite amount of milk or cream neither acid nor alkaline, but neutral, we can figure the amount of acid in the sample taken. To make such a determination we require the following:

1st. A standard solution of caustic soda, usually made of the strength known as .111 normal.

2nd. An indicator—some chemical which added to the milk indicates by change of color when enough of the alkaline solution has been added to render the milk neutral. Phenolphthalein is the one most commonly used for this purpose. It is made by dissolving 10 grams of phenolphthalein in 300 c.c. of 80 per cent. alcohol.

3rd. A burette, graduated to 1-10 of a cubic centimeter, in which to measure the amount of solution used.

4th. A pipette, to measure the milk or cream.

5th. A glass or porcelain cup, and a stirring rod. A complete outfit suitable for use in butter and cheese factories may now be procured from almost any of the dairy supply firms.

For the information of those who want to make their own alkaline solution or who may wish to check the strength of a solution on hand, the following directions are given:

Preparation of Solutions. The caustic soda solution may be prepared by a druggist or one who has a delicate balance at hand by carefully weighing out 4.4 grams of pure sodium hydroxide and dissolving in one litre (1000 c.c.) of water. But impurities in the sodium hydroxide and lack of delicate enough balance make this method unreliable.

The most accurate way of preparing this solution is by standardizing it against an acid diluted to the same strength as the alkaline solution wanted. As it requires an experienced chemist to prepare this acid of the strength required, it is important that it be got from a reliable source.

Having on hand then a .111 normal solution of acid, the object is to make a solution of the alkali, one c.c. of which will exactly neutralize one c.c. of the acid. For this purpose, dissolve about 5 grams sodium hydroxide ($NaOH$) in one litre of water. If the soda contains much carbonate, it must be removed by adding a little of a solution of barium hydroxide, boiling, and filtering off the precipitated carbonates. The relative strength of the acid and alkali solution is next determined. This is done as follows:

Rinse out a clean burette two or three times with the acid solution, and then fill it with the same. Note the exact point at which the surface of the liquid stands in the burette; measure out 10 c.c. of the alkaline solution, and deliver into a clean beaker, glass or porcelain cup. Dilute with about 50 c.c. of water, add three or four drops of the phenolphthalein indicator, and then stirring all the time let the acid from the burette drop slowly into the alkaline solution, until the color first produced by the indicator is just destroyed. This is the neutral point. Now, again note the exact point at which the surface of the liquid stands in the burette. The difference between the two readings is the amount of acid required to neutralize the 10 c.c. of alkali. If care be taken in coming to the neutral point slowly, it will be seen that one drop finally destroys the last of the light pink color. This work should be repeated until accuracy is assured. The following is an example of results:

1st. 10 c.c. of alkali required 11.5 c.c. of acid for neutralization.

2nd. 10 c.c of alkali required 11.45 c.c of acid for neutralization.

3rd. 10 c.c. of alkali required 11.5 c.c. of acid for neutralization.

In this case, we would accept 10 to 11.5 as the relative strength of the two solutions. The alkali is, therefore, the stronger, and must be diluted. If 1.5 c.c. of water be added to 10 c.c. of the alkali solution, 1 c.c. of the alkali ought exactly to neutralize 1 c.c. of the acid. Therefore, for every 10 c.c. of the alkali solution add 1.5 c.c. of water. Measure out the amount of the solution and pour into a clean dry bottle. Calculate the amount of water required to dilute the alkali to the proper strength, and add it to the contents of the bottle. Mix well, and test correctness of work by proving that 10 c.c. of the one solution will exactly neutralize 10 c.c. of the other. If it does this, the solution is correct.

Testing the Acidity of Milk or Cream. By means of a pipette (a 10 c.c. is a convenient size) measure out a definite quantity of the milk or cream to be tested and deliver into a beaker or cup. If distilled or rain water is handy rinse out a pipette once, and add the rinsings to the sample. Dilute with 50 c.c. of water, and add three or four drops of the indicator. Now, having the alkaline solution in the burette, carefully note the point at which the surface of the liquid stands in the burette and then cautiously let it drop into the milk or cream being tested. Keep the sample well stirred while adding the alkali. The acid in the sample will gradually be neutralized by the alkali added, until at last a uniform pink color appears, which will slowly fade away. The most delicate point is the first change to the uniform pink color, which the sample shows when the acid contained therein has been just neutralized. Because of the influence of carbonic acid of the atmosphere the pink color is not permanent unless a slight excess of alkali solution has been added. The operator should not, therefore, be led to believe by the disappearance of the color after a short time, that the neutral point has not been reached. Having decided on the neutral point, again read the burette at the surface of the liquid, and the difference between this reading and the first is the amount of alkali solution used to neuralize the acid in the sample taken.

The calculation of the per cent. of acid is simple. The alkaline solution used is of such a strength that when a 10 c.c. pipette is used, the number of cubic centimeters of alkaline solution required to neutralize the acid in the milk or cream has simply to be multiplied by 0.1. Thus, if 5.6 cubic centimeters of the alkali be used then 5.6 × 0.1 = .56 per cent. acid.

To insure accuracy the utmost care and cleanliness must be observed in every detail of the work. All water used with the milk or cream or in making the alkaline solution should be either distilled or pure rain water. The burette and pipette, after being washed, must be rinsed out two or three times with the solution they are intended to measure.

The knowledge the operator may gain from such tests will not only make it possible for him to turn out more uniform products, but it will also enable him to act with confidence and more intelligently to pursue the work he may have on hand.

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## MILK AND CREAM TESTING.

By J. A. McFeeters.

Normal milk may be considered as an emulsion. The chief constituents are fat, casein, sugar, albumen, a small amount of mineral matter—ash, together with a large percentage of water.

As fat is the most variable of the milk constituents the ability to accurately determine the percentage present is an essential qualification for a successful dairyman.

The importance of this becomes at once apparent under conditions where the commercial value of milk is in direct proportion to its fat content. A means of detecting mechanical losses, due to faulty methods in the course of manufacture, adulterations by the producer or dealer, or of testing the real worth of the different members of the dairy herd, is of inestimable value to a dairyman.

The details connected with an accurate, speedy fat determination of a normal sample of milk, by means of the Babcock test, are briefly as follows :

1. After thoroughly mixing, preferably by pouring from one vessel to another, a *representative* sample should be taken. Too great care cannot be exercised at this step. A test is of no value whatever if this point be overlooked.

2. By means of a 17.6 cubic centimeter (c.c.) pipette, take 18 grams of milk at a temperature of from 60 to 70 degrees.

3. Add to this 17.5 c.c. of commercial sulphuric acid with a specific gravity (sp. gr.) of 1.82 to 1.83, and thoroughly mix the acid and milk by giving the bottles a gentle rotary motion.

4. Place the bottles in the tester and whirl for from four to five minutes, at a speed varying from 700 to 1,200 revolutions per minute, according to the diameter of the machine (700 revolutions per minute with a machine twenty inches in diameter).

5. Add hot water at a temperature not lower than 140 degrees F. to float the fat into the neck of the bottle.

6. Rotate the machine again for about two minutes and take the readings before the fat cools. If troubled with burnt readings, add the water twice instead of all at once, filling the bottle just to the neck the first time, then turn the machine about a minute, fill to about the eight per cent. mark the second time, and whirl for another minute.

7. Read the fat column at a temperature of from 120 to 140 degrees F.

NOTES.

1. Always make sure that the pipettes and test bottles are clean before using.

2. Be very careful to measure the exact amount of milk for a test. A 17.6 c.c. pipette will deliver about 17.5 c.c. of milk. This measurement of milk of average quality will weigh about 18 grams.

3. A partially churned sample of milk may be prepared for sampling by heating it to about 110 degrees F.. and pouring it from one vessel to another, to mix it thoroughly. When it is thus prepared, take a sample as quickly as possible, and cool to about 60 degrees F. before adding the acid.

4. In sampling frozen milk it is necessary that both the liquid and the frozen part be warmed and mixed thoroughly. The unfrozen part is richer in fat and solids than the frozen.

5. A sample of milk that has soured and thickened may be prepared for sampling by adding a small amount of some alkali to neutralize the lactic acid, and cause the curd to redissolve. A small amount of powdered concentrated lye is very suitable. Add just a small amount of lye at a time, and pour the milk from one vessel to another, to mix the lye with the milk, which causes the casein to become dissolved.

6. The amount of acid used must be varied to suit its strength. The right amount is being used when the fat presents a bright golden appearance. Acid that is much too strong or too weak should be discarded, as satisfactory results cannot be obtained from its use. Acid a little weak is to be preferred to very strong acid. Carboys or bottles containing acid should be kept well corked, to prevent the contents from becoming weakened by absorbing moisture from the atmosphere.

7. Avoid pouring the acid directly on the milk. The test bottle should be held at an angle so as to cause the acid to follow the side of the bottle and go directly underneath the milk. After the addition of the acid to the test bottle the milk and acid should be in two distinct layers without any charred matter between them. A thorough mixing by means of a gentle rotary motion should be given at once.

8. If using a hand tester in a room at a low temperature, it may be necessary to keep sufficient hot water in the machines to maintain a temperature of from 120 to 140 degrees F in the test bottles.

9. The water added to the test bottles should be soft or distilled. If hard water is used, add a little sulphuric acid (half an acid measure, or a little more to a gallon of water) to soften it; this will prevent foam above the fat.

10. If there are several readings to take, *always* set the samples in hot water (120 to 140 degrees F.) extending to *the top of the fat* before reading.

11. It is well to use a pair of dividers or compasses for measuring the column of fat. The points of the dividers should be placed at the upper and lower limits of the fat column; then if one point be placed at the zero mark of the scale, the division at which the other point touches will show the percentage of fat in the sample tested.

12. Burnt or cloudy readings may be caused by:

(1) The use of too much or too strong acid.
(2) Allowing the acid to fall directly on the milk.
(3) Having the milk or acid at too high a temperature—the higher the temperature the less acid is required.
(4) Allowing a sample to stand too long after adding the acid, before mixing the milk and acid.

13. Light colored readings and floating particles of curd are usually due to:

(1) The use of too little or too weak acid.
(2) Having the milk or acid at too low a temperature—the lower the temperature of either, the more acid is required.
(3) Insufficient shaking of the bottles to unite the milk and acid thoroughly.
(4) Lack of required speed or time in whirling.

14. A convenient method of testing the accuracy of the graduation is to test the same milk in the different test bottles and compare the readings. A bottle that differs by more than .2 (2-10) in its reading from the rest should be discarded. As the capacity of that part of the neck over which the scale extends should be 2 c.c., the accuracy of the scale may be tested by filling the bottle to the bottom of the scale with water at the temperature of the room, and then adding 2 c.c. of water at the same temperature by means of a 2 c.c. pipette or a finely graduated burette.

15. Care and exactness in every detail are absolutely essential requisites for reliable results in milk testing. There is more to learn in *care* than in principle. Carelessness on the part of the operator has frequently thrown suspicion on the Babcock test.

## Composite Samples.

Whole milk creameries, and in many of the advanced cheese factories, the patron receives payment, not in proportion to the amount of milk, but in proportion to the butter or cheese value of the milk supplied by him. Such a system, of course, necessitates the use of the Babcock test. A test of the milk cannot be made daily; and to overcome this difficulty a small sample of the milk supplied by each patron is taken at each time of delivery and put into a bottle, called a composite sample bottle, which contains a small amount of some kind of preservative, such as bichromate of potash or corrosive sublimate. It is not advisable to use the latter alone, as it is quite poisonous, and imparts no color to the sample to indicate its presence. An excellent preservative is a mixture composed of about seven parts bichromate of potash to one part corrosive sublimate.

From what can be taken on a five cent piece to what can be taken on a ten cent piece will usually be found sufficient to preserve a sample for two weeks in summer and a month in fall and winter, when an ounce of milk is taken daily. The amount of preservatives required depends upon the weather, the size of the samples, and the length of time over which the testing period extends. A Babcock test of the sample is made at the end of two weeks or a month; and if the daily sampling and the testing of the sample are carefully done, it gives the average quality of the milk supplied during the time over which the test extends.

The samples may be tested twice per month, but by keeping them in a fairly cool place satisfactory results can be obtained by testing, but once a month.

## Notes on Composite Sampling and Testing.

1. For holding composite samples, pint jars with long corks are preferable. Turned wooden corks are more satisfactory than porous corks.

2. The jars should be kept well corked, as the samples will dry on the surface and a tough skin, composed largely of cream, will be formed when exposed to the atmosphere in warm weather.

3. Paste a plainly written label on each patron's jar, fasten its edges down well, and give it at least two coatings of heavy shellac to prevent it from washing off when cleaning the bottles.

4. Add the preservative to the composite sample jars at the beginning of the testing period, and before any milk is added to them. It may be necessary to add a little extra preservative later on. Be guided by the color of the samples and how well they are keeping. An excess of preservative has a strong tendency to produce burnt readings.

5. The sample for the composite jar should be taken after the milk is poured into the weigh can. For this purpose an ounce or a half-ounce dipper is often used. A tube or milk "thief" and a drip from the conductor are also satisfactory means of obtaining a sample. When receiving milk that is partly frozen, guard against taking a sample from only the unfrozen portion.

6. Give the jar a gentle rotary motion each time a sample is taken, to mix with it the cream that has risen and also to incorporate the fresh sample with the part containing the preservative; and avoid shaking the jar, as shaking tends to churn the contents.

7. It is sometimes necessary to place the samples in a cool place each day when through using them.

8. To prepare composite samples for testing: Set the sample jars in warm water at about 110 degrees F., to loosen the cream from the sides of the jars, and also to warm the samples to cause the cream that has risen to mix more readily with the milk. Mix well by pouring from one vessel to another—never by shaking. Should difficulty be experienced in getting a thorough solution, the addition of a small amount of potash will facilitate the operation.

When the composite samples for the Babcock test have been added to the test bottles, cool to about 60 degrees F., before adding the acid. One of the points most frequently neglected and underestimated is attention to temperatures. Sulphuric acid acts more strongly upon milk that is at a high temperature, than upon milk at a lower temperature; also the higher the temperature the more the fat will expand and the greater the reading will be. Adopt some *constant* temperatures for each step of the work; the following have been found very satisfactory. About 60 degrees for the milk when the acid is added, about 140 degrees for the water added to the test bottles, and between 130 degrees and 140 degrees for the water into which the test bottles are set before a reading is taken. If you prefer different temperatures from those suggested, adopt them, but do not neglect to adopt *constant* temperatures.

It sometimes is an advantage to add the water to the test bottles at twice rather than all at once, filling each bottle just to the neck at first, and to about the eight per cent. mark the second time. Whirl the tester for a minute after each addition of water.

9. Cost of testing composite samples: In a gallon of sulphuric acid there is enough for about 260 tests. Estimating the value of the acid to be 3½c. per pound, the cost of the acid for a single test would be one-quarter of a cent.

To find the average test of a number of samples: If the weights and tests of a number of different lots are fairly uniform, the average weight and test may be found by dividing the sum of the weights and tests by the number of lots, but when there is *no uniformity* in the different lots, the *true average* test can be obtained only by multiplying the total pounds of fat by 100 and dividing the product by the total pounds of milk. There is sometimes a wide difference between the mathematical average and the true average test of different lots.

## Testing Cream.

The need of an accurate, simple, and speedy method of determining the butter value of cream has become more and more urgent with the general adoption of the Cream Collecting System of Creamery management.

The Oil Test has been used for many years with a measure of success, but it may no longer be regarded as a reliable test for creamery work.

Its chief weak points and objections are as follows:

1. The readings or tests vary with the churnability of the samples. For example, a sweet sample, low in fat, will rarely yield an exhaustive separation of clear oil or fat. A low reading or poor test is usually obtained from such a sample.

2. The amount of labor involved in properly caring for the tests.

3. The machines used for the churning process are usually very noisy and often troublesome.

The Babcock test for cream has stood the test of several years' criticism and experience, and may be regarded as a simple, accurate, and satisfactory test for creamery work.

Cream test-bottles are graduated to read 30, 40, or 50 per cent. fat, and differ from whole milk bottles only in the diameter of the neck. The intermediate size is usually the most satisfactory for factory work. The scale on the neck of the ordinary milk or cream test bottle is graduated to read directly the per cent. of fat, only when 18 grams are used in the test, *i.e.*, the fat extending over one of the larger divisions of the scale weighs *one per cent.*, or the one-hundredth part of 18 grams. This fact will explain the various rules for determining the per cent. of fat when 18 grams cannot be used in a test—as in the case of cream and cheese, in which the per cent. of fat is high.

RULE. To find the per cent. of fat when less than 18 grams has been used; multiply the reading obtained by 18 and divide by the number of grams used.

This weight may be most accurately obtained by means of a delicate balance, but in the hands of the average dairyman it is a question if the use of a balance would result in greater accuracy than a pipette for sampling cream in a normal condition. The specific gravity of average cream (25 to 30 per cent.) being nearly *one,* the weight delivered by an 18 c.c. pipette would be approximately the required amount, viz., 18 grams.

During the process of cream ripening, however, more or less gas is usually formed which tends to reduce the specific gravity and thus lessen the weight of a given volume of the cream. It will thus be seen that sour cream sampled with a pipette would tend to give readings slightly lower than sweet cream. The difference in the test would scarcely be perceptible at a low per cent. of acid, but would be more marked at a high, sharp, acidy condition.

The use of a pipette for sampling in creamery work places a slight premium on sweet cream, thus affording a pertinent means of discriminating against overripe and otherwise objectionable grades of cream.

A sample containing an unusual amount of air or gas may be more accurately sampled if warmed to a temperature of about 110 degrees F. and after the necessary mixing, cooled to about 60 degrees F.

NOTES.

1. A pipette graduated to read both 17.6 c.c. and 18 c.c. is a convenience, the former measurement being required for whole milk, skim milk, butter milk, and whey, and the latter for cream.

2. When sampling viscous cream the pipette should be rinsed with about one-third measure of warm water, which should be added to the test bottle.

3. The addition of a small amount of caustic soda or concentrated lye to viscous or lumpy samples renders sampling more speedy and accurate.

4. Composite samples of cream may be cared for and treated in the same manner as outlined for milk under the heading, "Composite Samples." Page 18.

5. Sample jars should be kept well corked during warm weather to prevent evaporation. Carelessness in this matter may allow the samples to give off sufficient moisture to cause the test to read from 1 to 10 per cent. too high.

6. No specific measurements of sulphuric acid can be given for cream as some samples require more than others. The proper amount is being used when the fat column presents a clear golden color. It is well to use the minimum amount at first, and if a light shade is produced at the time of mixing, more may be added.

7. If troubled with cloudy or muddy readings, the addition of a few cubic centimeters of water to a sample before adding the acid is a good practice.

8. Experiments prove that after mixing the cream and acid the necessary hot water may be added before whirling.

9. Under favorable conditions, composite cream samples may be tested monthly. Under conditions where difficulty is experienced in preserving the samples it may be well to test semi-monthly.

10. As the Babcock test is based on weight, it is necessary to either weigh the cream or estimate the weight from the number of creamery inches. According to experiments conducted at the Ontario Agricultural College, an inch of average cream in a pail 12 inches in diameter will weigh 4.1 pounds. Thus, if it were found more convenient to measure the cream than to weigh it, the weight could be determined by multiplying the number of inches by 4.1. The number of pounds of cream furnished by a patron during a month, multiplied by the test, or the per cent. fat, and divided by 100 will give the number of pounds of fat which the cream contained.

11. A spring balance is a convenience when it is necessary for collectors to weigh cream at the farm. The use of these scales is allowable only when they pass the necessary Government inspection.

## The Oil Test.

This means of ascertaining the butter value of cream is still employed in a few sections, and is simply a churning process.

The cream collector is supplied with a pail 12 inches in diameter in which the depth of cream supplied by the patrons should be carefully *measured*. After thoroughly mixing the cream the collector should take a representative sample, filling the test tubes carefully to the mark, which should be five inches from the bottom.

To Make an Oil Test. Upon their arrival at the creamery, place the samples in a warm place, as over the boiler, and leave over night to ripen thoroughly. *They will not churn properly unless well ripened.*

The next morning place the samples in water at a temperature of about 90 degrees; and as soon as the cream will flow freely from one end of the tube to the other, place in the oil test churn and begin the churning. Should the cream at any time cool and thicken, place the samples in warm water to liquify the cream again. Continue churning until there is evidence of a clear separation of the fat; then place the samples in hot water, at a temperature of from 160 to 170 degrees, for from fifteen to twenty minutes.

If the separation be complete, the fat will be clear and yellow, and there will be three distinct columns with sharp lines of division between them, viz., a column of clear fat on top, one of whey next, and one of curdy matter at the bottom. If there be not a clear separation, cool to about 90 degrees, churn again and proceed as before.

To Take a Reading. There is a chart prepared for the purpose. Placing the bottom in an upright position on the "base line" of the chart, move it along until, when looking by the right side of the bottle, the top of the column of fat comes even with the uppermost slanting line on the chart. Next, still looking by the right side of the bottle, observe the line to which the bottom of the fat comes; the number on this line gives the reading.

A small rule made specially for the purpose is more convenient than a chart. This, however, will give a correct reading only when the test-tubes have been filled precisely to the mark. The chart consists of a sliding scale, and gives the proportion of oil regardless of the depth of cream taken or the diameter of the test-tubes

Sometimes the fat, though clear, is somewhat open. In such cases, or when the fat is not clear, allow the samples to become cold, and then place in water at a temperature of about 120 degrees F., before taking a reading. About 120 degrees is a very suitable temperature at which to take readings.

Meaning of the Reading. Cream that gives a reading of 100 in the oil test will make one pound of butter for every inch of such cream in a cream pail 12 inches in diameter; cream testing 120 will make 1.20 pounds of butter per inch. To find the pounds of butter, multiply the number of inches by the reading and divide by 100.

Theory of the Test. A standard or creamery inch is one inch of cream (in a twelve inch pail) testing 100.

One inch, therefore, contains 113 cubic inches. One pound of butter contains about 25 cubic inches of butter oil, which is 22 per cent. of 113. Therefore, any cream which will yield 22 per cent. of its volume in butter oil, will yield one pound of butter per inch. Tubes filled to the depth of 5 inches with cream which gives 1.1 inches of butter oil, will yield one pound per inch, as 1.1 is 22 per cent. of 5.

A reading of 100 by the oil test would, therefore, theoretically, be equal to 22 per cent. of fat.

The relation between the oil test and percentage of fat or Babcock test, may be viewed from the Babcock side as follows: The overrun in Collecting Creameries may vary from 12 to 13 per cent. to as high as about 18 per cent. Then 100 pounds fat would probably yield about 115 pounds butter.

1 pound of butter would thus be obtained from $\frac{100}{115}$ pounds fat.

1 inch of cream weighs 4.1 pounds.

Therefore in order to yield 1 pound butter per inch,

4.1 pounds cream must contain $\frac{100}{115}$ pounds fat.

1 pound cream must contain $\frac{100}{115}$ divided by 4.1 pounds fat ($\frac{100}{115} \div 4.1$).

100 pounds cream must contain $\frac{100}{115} \times \frac{1}{4.1} \times \frac{100}{1}$

Equal to 21.2 pounds fat.

According to experiments conducted at the Ontario Agricultural College Dairy School, the actual percentage of fat in cream yielding 1 pound of butter per inch is 21.1 per cent.

The relation between the value of a pound of fat and a pound of butter may be found to vary somewhat according to the percentage of overrun obtained.

With an average overrun of 15 per cent. and butter worth 17 cents per pound, the value of a pound of fat may be estimated as follows: A 15 per cent. overrun would prove 100 pounds fat to yield 115 pounds butter; 115 pounds butter at 17 cents equals $19.55; then 100 pounds of fat must be of the same value—$19.55. Therefore, 1 pound fat must be worth 19.55 cents. If *fat* were worth 17 cents a pound, the value of 1 pound could be estimated as follows:

100 pounds fat at 17 cents equals $17.00.

100 pounds fat should yield about 115 pounds butter, therefore, 115 pounds butter are worth $17.00.

1 pound butter is worth $17÷115 equals 14.78 cents.

With an average overrun and butter worth from 16 to 18 cents per pound the difference between the value of a pound of fat and a pound of butter would be from 2 to 2½ cents per pound.

## Skim-Milk Buttermilk, and Whey.

As the percentage of fat in skim milk, butter-milk, and whey is so small, the best method of testing these is by the use of the double-neck skim-milk bottle.

The usual amount of milk or whey is taken and the test is made in the usual way. Very fine readings can be taken, as a very small amount of fat will extend over quite a length in the small neck. Considerable controversy has taken place from time to time among the leading authorities as to how each division on the scale should be read, but it has been demonstrated that reading the first divisions as .1 ($\frac{1}{10}$) and each succeeding division as .05 (½ of $\frac{1}{10}$ equals $\frac{1}{20}$ or .05) gives results comparing quite favorably with gravimetric analysis.

Slightly more than 17.5 c.c. of acid may be used to advantage when testing skim-milk; it is also advisable to increase the speed of the tester or the length of time it is whirled.

The fat column in a double-necked bottle may be raised to any desired point on the scale by gently pressing with the finger on the mouth of the large neck.

It is not necessary to use quite the full amount of acid when testing whey.

The ordinary milk bottle is not suitable for testing skim-milk, buttermilk, or whey, as it is almost impossible to make an accurate reading of such a small amount of fat when it is extended over a broad surface.

## The Lactometer and the Detection of Adulterations in Milk.

The lactometer is an instrument used to determine the *specific gravity* of milk. The term specific gravity means the weight of a certain volume of any substance compared with the weight of the same volume of pure water at a standard temperature.

There are different kinds of lactometers, but the Quevenne is the most suitable for milk-testing. By means of it we can determine rapidly the relative weight of milk and water.

The Quevenne lactometer is standardized at a temperature of 60 degrees; if the milk to be tested varies from this, corrections may be made according to the following rule: For each degree in temperature *above* 60, add .1 ($\frac{1}{10}$) to the lactometer reading, and for each degree *below* 60, subtract .1 ($\frac{1}{10}$) from the lactometer reading. This rule is practically correct, if the temperature is kept within a range of from 50 to 70 degrees. It can be readily recalled when we remember that the density of milk *increases* with a *reduction* of temperature and decreases with a rise in temperature. The scale on the lactometer is graduated from 15 to 40, and indicates a specific gravity of from 1.015 to 1.040.

*Note.* The correct lactometer reading (or L.R. at 60 F.)+1000÷1000 indicates the specific gravity.

The lactometer reading of whole milk usually ranges from 29 to 34, although it may fall as low as 27, or go as high as 35. The lactometer reading of skim-milk varies from 33 to 38. The reading should be taken soon after placing the instrument in the milk; if cream be allowed to rise on the milk, the reading will be too high, as the bulb of the lactometer will be floating in partially skimmed milk. Milk should be cooled and allowed to stand some time (1 to 3 hours) after being milked before taking the lactometer reading. Otherwise the readings will be too low.

The composition of milk is about as follows:

| | | | |
|---|---|---|---|
| Fat | 3.6 per cent. | | |
| Casein | 2.5 " " | 8.9 | solids not fat. |
| Albumen | .7 " " | | |
| Sugar | 5.0 " " | | |
| Ash | .7 " " | | |
| Water | 87.5 " " | | |
| | 100.00 | | |

It is the solids-not-fat in milk that cause its specific gravity to exceed that of water, and consequently its lactometer reading to be greater than that of water.

A number of different formulas have been prepared for the calculation of milk solids when the lactometer reading and percentage of fat are known. As the percentage of solids-not-fat increases .25 per cent. for each lactometer degree and .2 per cent. for each per cent. of fat, the following formula has been very generally adopted:
(¼ + .2 fat. To find the *total solids* in a sample of milk, add ¼ of the lactometer reading to 1.2 times the per cent. of fat.)

The following rule is sufficiently accurate for practical purposes and has simplicity to recommend it: To determine the per cent. S.N.F., add the correct lactometer reading and per cent. fat together, and divide by 4. $\frac{L+F}{4} = \%$ S.N.F.

## Adulterations.

By the use of the Babcock test in conjunction with the lactometer, we are enabled to determine both the nature and the extent of an adulteration.

The percentage of fat in milk varies and can also be influenced by skimming, therefore the lactometer alone is of little use in determining adulterations. The solids-not-fat are fairly constant and thus afford a means of detecting adulterations.

*Watered Milk.* To find the per cent. of pure milk in a watered sample, multiply the per cent. S.N.F. in it by 100, and divide by the per per cent. S.N.F. in the pure milk. This subtracted from 100 will give the per cent. of extraneous water in the watered sample. To take an example:

The per cent. of solids-not-fat in a sample of pure milk is 9; but after being watered the per cent. of solids-not-fat in the watered sample is 7.2. Find the per cent. of pure milk in the watered sample.

Per cent. of pure milk in watered sample $\frac{7.2+100}{9}$ = 80 per cent.

Per cent. of extraneous water = 100 – 80 = 20 per cent.

*Note.* When a sample of pure milk cannot be obtained, use 8.5 in the early part of the season, and 9 in the later part, for the per cent. S.N.F. in pure milk.

The per cent. of *water added to the pure* milk may be estimated as follows: The per cent. S.N.F. in a pure sample, multiplied by 100, divided by the per cent. S.N.F. in the watered sample, less 100. The above may be worked as follows.

$\frac{9\times100-100}{7.2}$ equals 25 per cent. water added, or

To 80 lbs. pure milk, 20 lbs. water were added, then to

1 lb. pure milk, $\frac{20}{80}$ lbs. water were added.

To 100 lbs. " $\frac{20}{80}\times\frac{100}{1}$ lbs. water were added.

equals 25 lbs. water added to 100 lbs. milk or 25 per cent.

## Notes.

1. Have the temperature of the milk uniform throughout, and as near 60 degrees as possible when taking a lactometer reading.

2. Always mix the milk well before taking a lactometer reading.

3. Do not have milk on the upper part of the stem of the lacto-lactometer when reading, as this weighs the lactometer down and causes the reading to be too low.

4. Have the lactometer free from the side of the vessel, and perfectly still, when taking a reading.

5. A high lactometer reading accompanied by a low per cent. of fat indicates skimming, e.g., L. equals 34, F. equals 2.4.

6. A low lactometer reading accompanied by a low per cent. of fat, is indicative of watering, e.g., L. equals 22, F. equals 2.4.

7. A normal lactometer readng with a very low per cent. of fat indicates both watering and skimming. Also, if the lactometer reading of a sample of milk be low, yet not so low accordingly as the per cent. of fat, this is indicative of both watering and skimming. Both of the following indicate watering and skimming; L. equals 31, F. equals 2; L. equals 26, F. equals 1.8.

## Testing Cheese for Fat.

The fat content of cheese may be obtained by weighing from 2 to 5 grams, adding sufficient water to make up 18 grams and testing in the usual way.

$\frac{\text{Reading} \times 18}{\text{grams used}}$ equals per cent. of fat in sample tested.

Accurate and satisfactory results in testing may be obtained only by exercising the greatest care at every step in the work, coupled with sound judgment and experience.

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# HINTS ON THE CARE OF MILK FOR CREAMERIES AND CHEESE FACTORIES, AND CANADIAN CHEDDAR CHEESE-MAKING.

By W. Waddell and A. McKay.

Milk is the raw material from which the cheese or butter maker manufactures a valuable and concentrated food product. It is a perishable article and very susceptible to contamination; hence it is important that great care be taken to keep it sweet and free from any undesirable germs or taints. Milk should be supplied only from cows in good health furnished with an abundance of wholesome food, pure water, and having free access to salt at all times.

Cows giving milk should not be allowed to eat turnips, rape, foul weeds, musty or decayed food, or anything that will impart an objectionable flavor to the product, as injury to the milk from any cause results in a positive loss to the producer.

It is very important that there be no dust or bad odors in the stable at the time of milking, as the thin stream of milk passing from the teat to the pail will collect a large amount of any impurities that may be in the atmosphere. Before commencing to milk the udder and flank of the cow should be brushed or wiped with a damp cloth to remove loose hairs or fine particles of dust or filth. The milker should be clean, kind, and sympathetic and free from any contagious disease. Milking should be done quickly and as exhaustively as possible. Immediately after milking remove the milk to a clean, pure atmosphere and strain thoroughly to remove fine particles of dirt, as, no matter how carefully the milking is done there is likely to be some dirt in the milk, and this should be removed as quickly as possible. Special provision should be made for cooling the milk quickly to at least 65 degrees F., and for keeping it at that temperature over night, and to 50 degrees and holding it at that temperature if keeping the milk over Sunday. This may be accomplished by providing a tank large enough to contain cans holding at least two milkings and surrounding them with cold water. The milk should be stirred occasionally while cooling. A wire handled dipper should be provided for this purpose. Provision must be made for changing the water used to keep down the temperature. Ice is almost a necessity for keeping Saturday night's or Sunday's milk. The warm milk should in no case be mixed with that already cooled, and where possible send it to the factory in separate cans. If this is not done the morning's milk should be cooled before mixing with the evening's milk.

When purchasing tinware examine the seams carefully and see that all joints are well soldered so as to facilitate cleaning. Wash and cleanse thoroughly all utensils used in handling milk. First rinse them with warm water, then wash well with water at a temperature of 110 to 120 degrees and then scald or steam. Do not wipe with a cloth, but place to drain where they will get plenty of sunlight and pure air. Use a brush in preference to a cloth for washing tinware. A free use of washing soda will be found beneficial, but soap should not be used on milk cans or pails. The occasional scouring with salt will serve a good purpose. Wooden pails should never be used for milking.

The whole secret of keeping milk in good condition is cleanliness, and low temperature and under no condition should chemicals be used for preserving milk.

## The Curd Test.

Provide tin or porcelain cups sufficient in number to test the milk of at least half the number of patrons supplying milk to the factory. A convenient size would be two inches in diameter and four inches deep. Each cup should be plainly numbered. Provide a box of tin or galvanized iron with a neat fitting cover large enough to hold the cups. For convenience this box should have both steam and water connections. In taking samples for making the test place the number of the cup opposite the patron's name from whose milk the sample has been taken. When the samples have all been taken, place them in the box already described, adding water to the depth of the milk in the cups; raise the temperature to 86 degrees F.

Set the samples, by using one dram of a dilute rennet made of a strength of one part rennet to twenty-four of water. Stir in the rennet with a knife having a solid metal handle, being careful to sterilize the knife between the stirring of each sample so as not to contaminate one sample with flavors from another. When firm enough cut with the same knife, using the same precautions to sterilize between the cutting of each sample. Raise the temperature gradually to 98 degrees F., and handle the samples as nearly like the milk and curd in the vat as possible. In two and a half or three hours after setting pour off the whey. Keep up the temperature for three or four hours after this, and examine the samples occasionally for flavor by smelling and the texture by cutting with a sharp knife.

If looking for bitter flavor, and the milk is in a sweet condition, it may be advisable to add a few drops of culture to the samples before setting, as this flavor is rarely detected without the presence of acid.

This test is particularly valuable in detecting flavors which develop in the curd, but cannot be detected in the ordinary way when milk is delivered. It is also valuable for convincing patrons, who may doubt that the flavor of their milk is as bad as represented by the cheesemaker, as it is possible to have them see and smell the curd made from each patron's milk as delivered at the factory.

## The Preparation and Use of a Culture.

That there has been such a strong prejudice against the use of cultures in the minds of some of our best cheese buyers is not to be wondered at when we consider the careless slip-shod methods in which some makers prepare cultures, and the unrestricted use of them by others, regardless of the ripeness of the milk, or the acidity and flavor of the culture. The flavor of the culture used will largely determine the flavor of the cheese or butter made. Therefore, the need of full and exact knowledge of the proper method of preparing and using cultures is manifest.

First provide suitable cans. It is better to have a duplicate set if possible. Cans similar to the ordinary shot-gun cans whch are eight inches in diameter and twenty inches deep are quite suitable. When the milk is in small lots it can be more readily heated and cooled than if kept in larger quantities. For convenience in heating and cooling a special box or tank large enough to hold the cans containing the culture for one day's use should be provided. This should have steam and cold water connections. The cans may be left in this box so as not to be influenced by the outside temperature.

In starting a culture it is advisable to use a commercial, pure culture. These may be obtained from our Bacteriological department or from any of the dairy supply houses. Empty the mother culture into a quart of cooled pasteurized milk, and allow it to stand at a temperature of 75 degrees F. until coagulation takes place. Two per cent. of this culture may then be added to pasteurized milk at a temperature of 70 degrees for the next propagation.

After selecting the milk for culture, heat to a temperature of 185 degrees, stirring occasionally while heating. Allow it to stand at this temperature for 20 or 30 minutes, then cool rapidly to a temperature of 65 or 70 degrees F. To this milk add sufficient of the culture already prepared to develop an acidity of not more than .7 at the time the culture is required for use.

If the culture is to be kept for more than 24 hours, it is advisable to use a lower temperature—60 degrees F. or under. Aim to produce the same acidity from day to day. Before using, remove one or two inches of the milk from the surface of the can, as the surface is more liable to contamination from outside sources; break up the remainder by stirring well in the can. At this time take out a small quantity to propagate culture for next day. A glass sealer should be provided for this purpose.

The indications of a good culture are as follows: The whole mass is firmly coagulated, no liquid is found on top, and it has a milk acid flavor pleasant to taste and smell.

A culture may be used to advantage when the milk is maturing slowly or when it is tainted or gassy.

One-half of one per cent. is the greatest quantity which should be used at any time, and this quantity should be used only when the milk is known to be in a sweet condition.

Milk should be set slightly sweeter when culture is used. With gassy milk its use is especially beneficial. Culture with bad flavor or with too high an acidity should not be used.

A wire handled dipper is preferable for stirring milk for culture and all utensils must be thoroughly cleaned and sterilized after each time of using.

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## CHEESE-MAKING.

### Need for Improvement.

That there are some improvements being made in our factory buildings and equipment and in the sanitary condition in which they are kept cannot be denied, but it is also true that there is room for great improvement in this direction. We still have some factories that are not up to date and are wholly unfit for handling, in a sanitary condition, so delicate a food product as milk. We have also some makers who do not put forth the effort necessary for keeping their factories in a proper condition. The time has come when it is necessary that all interested in the cheese business join hands to have these hindrances to the best quality of our goods speedily removed. The training which our cheese-makers receive at the dairy schools should have a marked tendency to improve the appearance of the maker, and also the inside and surroundings of his factory. It has also been proved beyond a doubt that to make the finest quality of cheese, we must have our curing-rooms so constructed that an even and comparatively low temperature can be maintained. This should not be allowed to exceed 65 degrees in the hottest weather.

## Milk for Cheese-Making.

In the manufacture of cheese the first and most important matter is to have the milk delivered at the factory clean, sweet, and of good flavor. How this may best be accomplished is a subject that should engage the attention of all interested in the dairy business. We would suggest that our instructors spend as much time as possible among the patrons and with the assistance of our chemists and bacteriologists find out the causes and remedies for so much bad-flavored milk and cheese. We would urge upon makers the necessity of rejecting at the weigh stand all milk which is not in a fit condition for the manufacture of first class cheese, as receiving milk of this kind is a serious injustice to patrons supplying milk of good quality.

## Testing for Ripeness.

This may be done for setting, with the acidimeter or rennet test. Good results may be obtained by the use of either test. No definite degree of acidity can be laid down as a rule to go by. The proper rule is to set at the degree of acidity that will give the best results later in the process, or will allow the curd to remain in the whey until properly cooked, which will usually take from 2¾ hours to 3 hours from the time of setting the vat to the time of dipping the curd with the right amount of acid developed. This will be found to be slightly less than the acidity of the milk at setting as shown by the acidimeter.

In making early spring cheese it is usually necessary to make a quick-curing cheese in order to reach an early market.

To make this class of cheese it is advisable to use a large quantity of rennet and a small amount of salt, as this hastens the ripening process and overcomes the tendency in milk at this season to make a dry, harsh cheese due to the low per cent. of butter fat in the milk. Heat the milk to 86 degrees and stir slowly while heating.

If using the acidimeter and making colored cheese, the acidity should be taken before adding the color to the milk, as it is more difficult to detect, the neutral point with color added. Another point to note carefully when using the acidimeter for setting, is the effect of the presence of rain water in the milk. When the milk is diluted, less milk is taken in the sample, and will show a lesser degree of acidity than is contained in the milk to the extent of the percentage of dilution. If color is used it should be thoroughly mixed with the milk before the rennet is added, using one to one and a half ounces of color to 1,000 pounds milk. Add color in amount as the market demands it.

When the desired acidity is obtained add the rennet, using four to five ounces per 1,000 pounds milk or enough to coagulate the milk, fit to cut in 15 to 20 minutes. Commence to cut early, using the horizontal knife, first cutting slowly lengthwise of the vat, then with the perpendicular knife cut crosswise, and afterwards lengthwise, which will be sufficient for normal milk. Commence stirring at once with agitators or with a McPherson rake. Stir carefully for 10 to 15 minutes before applying heat, and be careful to have the curd all free from the bottom and sides of the vat before turning on the steam. Curd should be handled carefully, and in such a manner that the cubes will not be broken or allowed to mat together, as rough handling or breaking of the curd causes a serious loss in both quantity and quality. Heat to the cooking temperature of about 98 degrees F. in one-and-one-half hours from the time of setting. If using agitators, take them out in 10 or 15 minutes after the cooking temperature is reached. Remove at least half the whey, and keep the curd stirred sufficiently to prevent it matting. Acid usually develops very rapidly in the spring, therefore, it is necessary to be prepared to remove the whey quickly when enough acid has developed, which may be from .17 to .2 as shown by the acidimeter. Be careful to stir the curd dry. Curd must be well cooked and stirred dry if a fine cheese is expected. Leave the curd about eight inches deep in the curd sink. When it is well matted together cut into strips six to eight inches wide and turn upside down, and in about 15 minutes turn again and pile two deep. Continue turning every 15 minutes until the curd is ready to mill. When the curd is well matted and flaky, and shows .7 to .8 per cent. of acid it should be milled, and then well stirred afterwards. The stirring should be repeated often enough to prevent the curd matting until ready to salt. This will be when the curd has mellowed down nicely and shows from 1 to 1.2 per cent. acid. Stir the curd well before adding the salt to give the cheese good body and improve the flavor and texture. Salt at the rate of 1 1-2 to 2 pounds of salt to 1,000 pounds milk. It is important that the temperature of the curd from dipping to milling be about 94 degrees. After milling, allow the curd to cool gradually to about 85 degrees when ready to salt. Put to press at a temperature of 82 to 84 degrees. Weigh the curds into the hoops; tighten the press gradually and leave the cheese 45 to 60 minutes before taking out to dress. When dressing use plenty of clear hot water, and what are commonly called skirts. These cloths help to make a good rind on the cheese and keep them clean and cause the cheese to come out of the hoop more readily. Turn all cheese in the hoops every morning and allow no cheese to be taken to the curing-room that are crooked, have wrinkles in the bandage, or rough edges.

## Summer Cheese.

In making summer cheese one ounce of color per 1,000 pounds of milk is usually enough, but this may be varied according to the requirements of the market. Use from three to three-and-one-half ounces of rennet extract per 1,000 pounds of milk, or sufficient to coagulate the milk fit to cut in 25 to 30 minutes. The cutting and cooking of the curd is the same as given for spring cheese.

It may be necessary in some cases to raise the cooking temperature slightly higher, or to about 100 degrees, shortly after normal cooking temperature is reached. The whey should be partially drawn off and the curd well stirred by hand or with a rake to insure thorough cooking. The acidity should be allowed to develop to such a point that is found from day to day to give best results in the working of the curd later in the process, aiming to have the curd with good body, well matted and in a flaky condition when ready to mill. At this time it should have an acidity of .75 to .85 in 1¾ to 2 hours from the time of dipping. Curd should be well stirred after milling. Care must be taken not to salt the curd too soon as open cheese may be the result. Curd should be well ripened, stirred and aired thoroughly and cooled to a temperature of 85 degrees before salting. Use from 2 to 2½ pounds of salt to 1,000 pounds of milk.

## Fall Cheese.

In making fall cheese it is a mistake to use too much culture, or to ripen the milk too much, giving the cheese the appearance of having been made from over-ripe milk, which is very objectionable. Rather use a smaller amount of culture, not more than 1-4 of one per cent. and add it to the milk as early as possible, then allow the milk to ripen. Always heat the milk to at least the temperature of the culture before the culture is added. Set slightly sweeter than usual, as we are able to work closer to the sweet line all the way through when culture is used.

## Gassy Milk.

The presence of gas in milk retards the development of acid, and as acid is necessary in the manufacture of cheese we should make the conditions as favorable for its development as possible without injury to the body of the curd. To do this, use ¼ to ½ per cent. of good culture, ripen slightly lower for setting than for normal milk, when cutting aim to have the cubes even in size and as large as possible, allow the acid to develop slightly farther before applying heat, stir carefully, and heat slowly, aiming to have the curd in normal condition at dipping. Use the same cooking temperature and the same acid for dipping as with a normal curd. A gassy curd does not require so much stirring, as the moisture leaves the curd more readily. Cut and turn as usual and pile according to the body of the curd. Mill as soon as the curd is well matted, and the acidity has developed to .8 to .85

per cent. About half way between milling and salting, commence piling the curd, allow it to stand for 15 to 20 minutes then spread out, stir well and pile again. Continue to do this until the curd is nice and mellow. Give plenty of fresh air before salting. Use a normal amount of salt, and put to press at a temperature of 80 degrees, if possible.

## Over-ripe Milk.

This class of milk should be avoided, as the loss is too great, even when handled in the best possible way. The heat should not be applied till milk enough is in sight to fill the vat, and then heat as quickly as possible to 82 or 83 degrees, and after testing for acidity, set at these temperatures using one ounce extra of rennet per 1,000 pounds milk. Stir for about two minutes. Commence cutting early and cut fine, using the horizontal knife for the fourth cutting, cutting lengthwise of the vat. Where possible use a finer knife than usual. Cook quickly and if necessary raise the temperature two or three degrees higher than for normal milk. Run off the whey as soon as possible, and stir the curd well in the small amount of whey before dipping, so as to have the curd well firmed before sufficient acid is developed. Dip with slightly less acid where possible. Stir dry, and if the curd has been well handled, treat the same as a normal curd. If the curd is not well cooked and the moisture properly expelled from it, mill early and ripen well before salting.

## Ripening or Curing Cheese.

The ripening or curing of cheese is one of the most important points in the whole process, as no matter how well a cheese is made if the curing is not properly done the quality cannot be the finest. Hence it is a necessity to provide a room where the temperature can be controlled at all times. It is important that some means be provided to control the moisture in the room to prevent the growth of mould which occurs when too much moisture is present. An excessive shrinkage takes place if there is too little moisture in the room. This may be accomplished by building an ice chamber in connection with the curing room and having a free circulation of air over the ice. This cools the air and causes a deposit of the moisture on the ice.

In putting the cheese into the curing-room, place them straight and evenly on the shelves and turn them every morning except Sunday. Keep the room well swept and looking neat and tidy.

Use good strong cheese boxes. Have them dry and made to fit the cheese neatly. Put two scale boards on each end, weigh carefully and stencil the weights plainly on the boxes. Load the cheese on clean wagons, and have canvas covers to protect them from rain and heat while on the way to the station.

## SEPARATORS AND THE SEPARATION OF MILK.

By R. W. Stratton.

In dealing with this subject, general directions only can be given. Space will not permit giving detailed directions for the different makes of separators. A book of directions is furnished with each new separator sent out, and the specific instructions contained therein should be strictly followed unless you know of something better, which you have proven to be so by practice, not theory. Separators may be divided into two classes—the steam or turbine, and the belt separator.

### Turbine Separator.

In setting it up, a solid foundation should be provided. It does not matter how solid a wooden floor is, it will vibrate more or less from the running of a churn or other machinery. With a stone, brick or cement foundaton a separator is independent of any vibration from other machinery and will run much better, and for a longer time. If setting the separator on a cement floor probably the most permanent method of fastening it down would be as follows: First mark the exact location for the holes. With a square draw a line through the centre where the holes should be, then drill the cement to the desired depth (6 to 7 inches). To do this a common cold-chisel may be used providing the bit is wide enough for the body of the chisel, though a pointed chisel for this purpose is preferable. The dust may be removed from the hole while drilling by a small bellows, or blowing through a small rubber or glass tube. Have the bolt head somewhat rounded and place the bolt in the hole with the threaded end up, making sure to have it perpendicular and in line, and the necessary height above the floor, then pour melted lead in the hole around the bolt. If a method is desired whereby the bolts can be removed from the floor, drill holes as above, plug with wood, bore with a bit at least ⅛ of an inch smaller than the lag screws used and fasten down with lag screws. Another method whereby separators may be changed without drilling new holes is to drill the holes in the cement nearer to the centre than any separator will be likely to require, fasten a 2 inch by 4 inch piece of wood to the floor and bolt the separator to it.

In putting down a cement floor to be used for separators, it is well to have a pier built about two inches higher than the floor and about the size of the separator base. This tends to prevent dirt from lodging under the separator when scrubbing the floor.

If a stone or brick pier (bricks are neatest) has to be built, the nature of the soil will determine the depth to excavate, and the size of the frame or base of the separator will determine the length and breadth. The exact specifications are given in the book of instructons furnished with the separator.

Place the separator in position, being careful to have the separator frame perfectly level every way. Determine this by placing the spirit level upon the planed top of the frame.

The pipe to convey the steam to the separator may be the same size as the fittings of the separator, provided the distance from the boiler is not over twenty-five feet. When there is more than this distance the size of the pipe should be one-quarter inch larger for every twenty-five feet of piping, to overcome friction and condensation of steam.

Exhaust pipes are usually made of galvanized iron, and should never be reduced in size at any point, smaller than the outlet on the separator, and should be put up as straight as possible to convey the steam from the separator. It may be carried out at the side of the building. In either case, a piece extending upwards should be put up to cause a draught. Placing the exhaust pipe out through the roof is preferable when the surroundings will permit it. Have the pipe long enough to be higher than any part of the roof, in order that the draught may not be interfered with by change of wind. A drain pipe must be provided in any case at the lowest point on the pipe, to allow water to escape readily. If this should be in the making-room, a trap to prevent annoyance from escaping steam may be put on the drain pipe.

## Belt Separators.

The directions given for the foundation of a turbine will apply to this. First place the intermediate or jack in position. This should be at an angle of at least 45 degrees in front or behind the driving shaft. Level it by placing a level perpendicularly on the planed rim of the separator pulley of the intermediate. Be sure to have the shaft of the intermediate parallel with the driving shaft.

The pulley provided for the driving shaft should be of sufficient width to allow the belt to be shifted from the tight to the loose pulley of the intermediate, and of the proper size to give the exact speed required. Next place the frame of the separator in position. Level it in all directions by placing the level on the planed top of the frame. Line the separator with the intermediate, so that looking from the intermediate the right hand edge of the small pulley of the separator is in line with the right side of the large pulley of the intermediate, having the vertical centre line of the spindle pulley level with the underside of the intermediate pulley.

The separator bowl should revolve to the right, or with the sun, the same as the hands on a watch. The intermediate should run from the separator, so as to place the draw belt on the upper side of the intermediate pulley, with a view to remove some of the weight of the bowl from the foot-step bearing when the separator is running. If an idler or belt-tightener is used, always place it on the "return" side of the belt—*never* on the "draw" side.

Do not use the belt tightener any more than is absolutely necessary as it shortens the life of the belt very materially. It would be an improvement if the intermediate could be adjusted to suit the stretching of the separator belt.

Wipe all the bearings well with a cloth, to remove all grit and dust. A little coal oil upon the cloth will be found helpful where any coating of dried oil is met with. See that all oil tubes are clear and free to feed the oil. Wash the bowl and all parts that the milk comes in contact with. If everything has been properly attended to as directed it is ready to start. If a turbine, turn on steam very gradually to allow the water to get out of the steam pipes, when the required amount of steam may be turned on. When speed has been reached, start the feed of milk.

If a belt machine, and only one in use, put all belts in position, and start the engine slowly, allowing the speed to increase gradually. If more than one separator is used, it is better to start the engine at full speed, then shift the belt from the loose to the tight pulley after starting the separator by pulling the belt with the hand until the bowl has attained some speed. Then shift the belt from the loose pulley part way on to the tight pulley, moving it at intervals until on full. From 6 to 10 minutes should be required to get up speed. Full speed is ascertained by means of speed indicators. A 100 notch wheel should be counted for one minute, and a 50 notch wheel for one-half a minute, in order to know the number of hundred revolutions the bowl is revolving per minute. After speed has been reached, the milk should be turned on full feed, until both cream and skim-milk flow from the respective spouts; then it should be closed off until the cream is of the desired thickness. The cream should be the guide in operating the separator.

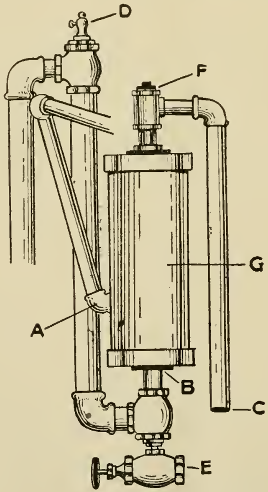
The cream left in the bowl when all the whole milk has been put through should be forced out with warm water. From one to two pails will be needed for this purpose. Shut off the feed-tap for a few sconds when about half the quantity has gone through; then turn it on again allowing the remainder to complete the operation. Pure warm water is preferable to skim-milk, as it is nearer the specific gravity of the cream, and consequently displaces it more readily.

Allow the bowl to stop of its own accord after the power has been removed; never apply any brake or friction to the intermediate. Remove the solid matter found at the extreme outside of the bowl and burn it at once. Clean out all milk tubes with the spiral provided; wash with tepid water thoroughly; scald with steam or boiling water; then place on a draining rack where the bowl and its parts may dry. Never close the bowl when wet inside as it will cause it to rust. Leave it open when not in use so it will be thoroughly dry.

In ordering the parts for the separator always specify exactly what is wanted by the use of the proper name and number of the same. This can be found by consulting the book of instructions furnished with all machines. A duplicate set of the delicate or wearing parts of any machine should be kept on hand for emergencies.

Milk fresh and warm from the cow is in the best possible condition for a perfect separation. The difference in specific gravity between the fat and other portions of the milk is then greatest, and it is also more fluid, as there is no development of lactic acid, nor chemical changes due to its exposure to the air. At the creamery, it is not met with in this favorable condition; consequently it is necessary to produce artificially as many of the favorable conditions as possible to get the best results. When milk is received at a temperature below 85 degrees, it should be heated to from 90 to 100 degrees.

A tempering vat should be elevated at a suitable height, to allow the milk to flow into the separator; and it should contain enough milk to em-




SKIM-MILK PASTEURIZER USING EXHAUST STEAM.

A. Milk inlet 1¼" pipe. B. Exhaust steam inlet 2" pipe. C. Overflow 2". D. Small valve on exhaust steam pipe to prevent suction of skim-milk back into steam pipe. E. Valve to drain heater. F. Plug which may be removed in order to see if heater is filling with material from skim-milk. G. Heater 6" diameter. 18" long with caps screwed on each end.

ploy the separator for at least four minutes. If large bodies of milk are heated to the desired temperature in a vat before separating, acid develops too rapidly and clogging of the separator bowl is likely to follow. Should any accident happen whereby the separator is stopped, the milk would likely develop acid enough to thicken, when it could not be separated.

While it is doubtless true that better butter can be made by pasteurizing the whole milk before separating, still the improvement is not enough to compensate for the extra labor required in cleaning the separator and utensils. There is also the fact that the separator bowl will need to be retinned often if separating pasteurized milk.

The plan followed at the Dairy Department at the present time is to heat the milk to about 95 degrees before separating. The cream is delivered from the separator into the pasteurizer and heated to 180 to 185 degrees. The skim-milk is elevated by a rotary pump and just before entering the tank it passes through a heater in which exhaust steam from the engine is used for pasteurizing the skim-milk. The cut will show how this heater may be made. A union should be put in the steam pipe somewhere near the heater, as the heater will need to be taken apart at intervals to be cleaned. This can best be done by burning in the furnace. The amount of milk, and the temperature to which it is heated will determine how often it should be cleaned. Usually it will run from six to eight weeks without requiring to be cleaned.

A great saving in fuel can be made by utilizing the exhaust steam from the engine. At the Dairy Department the pipes are so arranged that the exhaust steam can be used for heating the whole milk before separating, heating water, pasteurizing the skim-milk, and heating the building.

Two other labor and trouble saving devices are in use at the dairy which are worthy of special mention. One is a skim-milk weigher which after four year's use we would find it very difficult to get along without. The other is an Ideal hoist for elevating milk at the intake. Having the driveway graded so that no lifting of the can is required is the best plan, but where this cannot be accomplished, the Ideal hoist would seem to be a very satisfactory means of elevating the milk.

Pulleys and Belting. The following rules for finding the size of pulleys, and the required length of belting will be found useful, in fitting up a creamery or in placing additional machinery.

To find the diameter of a driven pulley, multiply the diameter of the driver by its number of revolutions, and divide the product by the number of revolutions the driven pulley should go. The result will be the diameter of the driven pulley.

*Example.* Diameter of pulley on the engine, 40 inches; speed of engine, 160 revolutions; speed in main shaft, 200 revolutions: $40 \times 160 \div 200 = 32$, which is the diameter in inches required for the driven pulley.

To find the required size of a driving pulley, multiply the diameter of the driven pulley by the number of revolutions it should make, and divide the product by the revolutions of the driver.

*Example.* Diameter of the pulley in intermediate is four inches, which is required to run 900 revolutions per minute. Revolutions of shaft 200. $4 \times 900 \div 200 = 18$, which is the diameter in inches of the pulley required to drive the intermediate at proper speed.

To find the length of belt for any two pulleys, add the diameter of the two pulleys together, divide this sum by 2, and multiply the quotient by $3\frac{1}{4}$. Add the product to twice the distance between the centres of shafting, and the result will be the required length of belt.

*Example.* Two pulleys are 8 and 24 inches in diameter, and 8 feet is the distance between the centres of the shafting. $8+24=32$, $32\div2=16$, $16\times3\frac{1}{4}=52$ inches$=4$ feet 4 inches, and 4 feet 4 inches$+16$ (twice the distance between the centres of the shafting)$=20$ feet 4 inches, which is the length of belt required.

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## CREAMERY BUTTERMAKING.

By C. W. McDougall.

The practice of the art of buttermaking must always be one of evolution. Advancement is an assured result when we earnestly endeavor to make our practice conform to methods that have been proven to be superior to our own. These superior methods may be the result of scientific investigation or of the intelligent observation of practical men. To teach any method as an infallible one would be assuming a false position. The claims made for the perfection of the method would in reality be a reflection upon the intelligence of the scientists and buttermakers of the future. On the practical side of the question, however, we know that we do not adapt with sufficient readiness methods which would produce a marked improvement.

We should all like to have our supply of milk and cream in what we now think is first class condition, and have the butter made in a modern creamery by the most improved method. Granting that we accomplish all this, we should find that there still remains room for much investigation and improved practice. When we recognize this fact where are we to look for justification in our too common method of blundering along in the dark at the mercy of so many foes? It would be quite difficult to find a more unscientific practice than that of some of our buttermakers at the present time.

On the farm, the intelligent production of milk and the proper care of this milk, or the cream obtained from it, are very essential factors in the manufacture of good butter. This is especially true in the case of creameries operated on the cream-gathering system, for here each patron becomes to a large extent a buttermaker as he handles the cream at one of the most important stages of buttermaking. It is to be taken for granted that all creamery patrons know the value of having good cows supplied with an abundance of good food, pure air, water, etc. On these we must depend for the natural flavor or individuality of the milk or cream, and it may be said on behalf of our creamery patrons that very little complaint can be made on account of poor flavored milk at the time it is taken from the cow. But when we consider the length of time the milk or cream is cared for by the patrons, and the quality of this care, we find evidences of inexcusable neglect. To take wholesome milk from a kind and generous cow amid foul surroundings and deliberately put it into unclean pails, through unclean strainers, run it through a filthy separator, or leave the milk or cream at a high temperature, is nothing short of a crime against the state. As soon as milk is produced it begins to decay, and the rate at which this decomposition takes place will almost entirely depend upon the amount of dirt which has been incorporated with it, and upon the temperature at which it is held. On these two points there is still much room for improvement.

It is practically impossible to avoid getting at least a small amount of dirt into the milk, and with this dirt are introduced countless numbers of bacteria. At this stage we must act with promptness to prevent as far as possible the harmful effects of these bacteria. Where the milk is to be sent to a whole milk creamery, cool at once to a temperature of 60 degrees or below, cooling Saturday night's and Sunday morning's milk much lower. The holding of cream for two, three, or more days is a very bad feature of our cream-gathering system. This means the hopeless destruction of fine butter quality in the cream unless ample preparation is made for, and thorough care taken of, each lot of cream. Treatment that will assist in retaining this fine butter quality is to be found in skimming a rich cream, pasteurization, or holding the cream at a low temperature. The cream separator furnishes the best means of getting a rich cream, but if we cannot get a separator that will do close skimming, while delivering a rich cream and that can be purchased at a reasonable price, we are better without one. The serum or skim-milk portion of the milk furnishes the bacteria with food for growth and reproduction, the fat in itself not being a bacterial food. For this reason the more milk drawn off as skim-milk the few bacteria we have in the cream and the less serum for them to feed upon.

The cream from the separator should test not less than 30 per cent. fat. A rich cream gives the buttermaker better control of his part of the process as well as being beneficial to the patron. The cream should be cooled immediately to at least 45 degrees. This temperature applies to all creams to be sent to a creamery whether they be from the centrifugal or gravity methods. Pasteurization is a very efficient method of preservation. The heating and extra cooling, however, mean more work and expense than would be considered practicable under average conditions. Nature, in her kindness, has in this country supplied us with an abundance of ice for keeping our cream cold, but the average creamery patron simply ignores this fact, supplies a cream out of which a first class butter cannot be made, and then grumbles at everyone but himself when he is reaping the reward of his own transgression.

A great many creamery patrons will argue that cream is not sour until it has coagulated or thickened, whereas about half of the possible acidity is produced before this condition is noticed. Cream must be in good condition when taken up by the cream hauler so that good butter can be made from it after being on the cream wagon and in the creamery for the greater part of a day. The fact of a cream hauler accepting a patron's cream is certainly not the end of that patron's responsibility.

The transportation of cream in cream tanks and the ignorance and indifference of the cream-gatherer have permitted abuse in putting poor lots of cream into the tanks. It is true that the tanks and jacketed cans in use are important factors in maintaining a low temperature of the cream, but the abuses connected with their use would seem to make the adoption of the individual can system very desirable.

The adoption of the individual can system permits of the rejection of poor cream or the proper recognition of the patrons supplying good cream by payment according to quality. In addition to this the possible abuses existing through the work of the poor cream hauler are largely avoided, and the chief qualification of all cream haulers under this system consists in their ability to deliver the cream at the creamery in the shortest possible time.

To have a good flavored, rich and sweet cream furnished by the patrons, and to have this cream taken under first class conditions to the creamery, at least three times a week, would materially aid in the improvement of the quality of the butter.

That part of buttermaking which is more directly the work of the creamery operator and manager is a very large one and is weak on many sides. We are not lacking so much in technical knowledge or instruction as we are in the intelligent application of principles we already know. If we are to keep a choice butter for home or export market in view, we must admit that our average creamery is lacking in such essential equipment as a pasteurizer and cooler, and has only an apology for a butter storage. We have too many poor creameries with an equipment that is not at all up to date. Of course, it can be argued with good reasoning, that the construction, equipment, and consistent operation of an ideal creamery may be a poor business venture, but this is not sufficient excuse for our common method of endeavoring to get sufficient cream to make a large quantity of medium grade butter at a minimum cost or maximum commission in manufacture. A creamery must have sufficient cream to make its operation practicable, but associated with this should be the rejection of poor cream and the handling of the remainder in the best possible manner. We owe this to our good patrons before we are reasonably entitled to their patronage. If we are going to improve the quality of our export butter we must prove ourselves greater masters of the essentials embodied in this improvement.

Sufficient work has been done in the churning of sweet pasteurized cream to demonstrate that the butter made by this method has an excellent keeping quality.

Good methods of work vary, but the following outline is good practice. The cream is pasteurized at 185 degrees and cooled to a temperature of 40 to 45 degrees if to be churned as soon as separated. This low temperature practically necessitates a cream cooler operated in connection with a mechanical refrigerating plant or by pumping through the cooler the brine from a tank containing cold brine or water and ice. As high as 30 per cent. of the good culture may be used to advantage. When the milk is inferior skim a very rich cream and use a high per cent. of culture. When the cream is to be held until the following day, add little or no culture if the quality of the milk is good; if the quality is not good, skim a rich cream and dilute with good whole milk and culture, or skim-milk and culture especially selected. Churning the cream the following morning will give a more exhaustive churning than if churned immediately after separating and cooling, and so low a temperature for solidifying the fat will not be necessary. As in ripened cream the same principles guide the churning operations, though special precautions should be taken to avoid churning too quickly. A cooling of the culture before adding it to the cold cream will prolong the churning period by making a lower average temperature of the contents of the churn.

It should be our aim to pasteurize all cream to be used in butter-making. This will be beneficial in all cases when the highest quality of the butter is being considered, and will permit of a much lower cream acidity to produce an equally exhaustive churning. Keep the temperature of the cream at the pasteurizer up to 185 degrees.

The period of cream ripening is one of decomposition and should be under positive control. The production of high acid should be avoided in even pasteurized cream unless a higher flavor is needed for local or special market. Four-tenths of one per cent. acid is sufficient. In the handling of any cream, the use of an efficient cream cooler is very desirable. The absence of a modern cream cooler in our creameries is, season after season, causing excessive losses of fat in the buttermilk and decreased quality of the butter.

In unpasteurized cream as low an acidity as will produce an exhaustive churning should be used. This could be increased where a higher flavor is demanded or where an acid flavor will be less objectionable than a poor flavor already present. The temperature should be uniform throughout the cream, as the portions of the cream remaining at the higher temperature have their churnability increased both by the increased lactic acid development and decreased solidifying effect of the higher temperature, while the portions remaining at the lower temperature have churnability decreased both by the decreased lactic acid development and greater solidifying effect of the lower temperature upon the fat globules. Uneven ripening temperatures means extra losses in the buttermilk and uneven granules during churning. The resulting condition is really uneven amalgamation of the fat globules during the operation of churning. If an exhaustive churning of unpasteurized cream can be had below .55 per cent. acid do not exceed this amount.

Avoid extremes in the length of time for churning. From 30 to 45 minutes is good practice. Endeavor to get a balance of conditions from the amount in the churn, speed of the churn, quality of cream, etc., so as to have ample and uniform concussion of the contents. Do not churn very rich or thick cream in churns having internal projections or pockets that furnish a place for lodgment of the cream.

Avoid high and very low churning temperatures; a fairly low one is preferable. Endeavor to get body in the fat globules by using a low ripening temperature. A vigorous growing lactic acid culture will produce sufficient acid at a temperature of 50 degrees. Draw off the buttermilk as soon as it will readily separate. Having the granules small when the buttermilk is removed, thoroughly rinsing them, then adding sufficient water and increasing the size of granules to that of large corn is good practice. Endeavor to get angular granules and avoid very low or high temperatures of the wash water. Wash water very low in temperature makes a condition favorable for the production of mottles while the high temperature creates a condition demanding great skill. Having naturally firm granules, and using a fairly high temperature for the last wash water, are productive of greater overrun and is quite practicable under control conditions. Do not practice it if you are not in a position to counteract the risks entailed. In all cases, only wash water which is pure should be used. All doubtful water should be subjected to a chemical and bactericlogical analysis before using.

The best salt obtainable should be purchased and care should be taken to store it in a dry place which is free from tainting odors. If preservative is used it should be evenly mixed with the salt. An ordinary flour sifter suits admirably for this purpose. Sift or spread the salt or salt and preservative onto the butter as evenly as possible, doing it in three or four applications, turning the butter each time. The best distribution in working, and the most economical use of salt is obtained by having a moist granule with a small amount of free wash water and relatively a small working area. After the butter has massed, open all faucets to permit of the ready escape of free brine.

The proper amount of working to be given to the butter will be best ascertained by observing the results of different amounts under the one system for successive days. We must secure an even distribution of the salt and expel an excess of free moisture. A slightly overworked condition of the butter is preferable to a mottled condition even if the grains be better in the latter.

All butter packages should be neat, strong and made from non-tainting material. Perfect cleanliness should be observed in lining and packing all boxes or tubs and in wrapping prints. The market to be supplied will largely determine the style of package and manner of packing Only the very best parchment paper should be used, and it should be cut while dry so as to finish neatly when the package is filled. Soak the parchment for twenty-four hours in a saturated solution of salt; if sufficient formalin is added to this brine to destroy mold, the incorporation of the mold spores will be prevented. Add small amounts of butter at a time to the package, in order that the packing may be more thoroughly done. Pack in considerably more than the requisite amount, and then, by means of a straight edge, cut out to a weight which will allow for ample shrinkage. The impressions of a fluted roller on this surface will relieve it of its plain and sometimes greasy appearance. Fold the parchment over the butter as neatly as possible. The preservation of the butter is best obtained by putting it into low temperature storage as quickly as possible.

Eternal vigilance is the price of keeping a creamery and its equipment in good condition. Dirt and conditions favoring its collection demand prompt and thorough attention. These are factors in the purchase of all creamery machinery and utensils. Machinery should be purchased subject to a test under practical conditions, and efficiency rather than first cost should be the guide in purchasing.

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## HAND SEPARATORS.

By Geo. R. Taylor.

The hand separator problem is one of the most important questions before the dairymen, and especially the creamerymen, of our country at the present time. When the whole milk system of buttermaking was in vogue, the buttermaker had control of nearly all the conditions which tend toward the production of a high grade product. The milk then had to be in a sweet condition when it was received at the creamery or it could not be separated. This being the case, the buttermaker had pure, sweet cream to work with, and he was held responsible, and justly so, if a first class product was not manufactured. With the general adoption of the cream-collecting system of buttermaking, however, a much different state of affairs exists. The patron of the creamery separates the cream from the milk, either with a hand separator or by other means. The cream is delivered at the creamery, once, twice, or three times a week, and owing to various causes, is too often received in a very poor condition. The buttermaker may then try to make a first class quality of butter, but will often meet with only a small measure of success. It is important, therefore, that the patron should understand how to operate a separator to get the best results, and also understand the principles to be observed in caring for the cream.

Some of the most potent causes of poor cream are:

1. Improper care of the cream after separation.
2. Having the separator in an impure atmosphere.
3. Carelessness in washing the separator, or neglecting to wash it each time after being used.
4. Skimming a cream too low in butter fat.

Carelessness or neglect in washing the separator, separating the milk in an impure atmosphere, or carelessness in caring for the cream are the common causes of bad flavors in the cream, and in each case the trouble may be easily overcome by a little extra care on the part of the person operating the separator.

A cream poor in milk fat, or one containing a large amount of skimmilk is objectionable for many reasons, both to the farmer and to the creamery man, and the separator agent who advocates the practice of skimming a thin cream and washing the separator once a day or only when convenient, is not working for the best interests of the dairy industry. Agents who advocate such a practice have only one object in view, and the machines which they are offering for sale are likely to be either separators that are hard to wash, or those that are not well adapted for skimming a cream containing a high percentage of fat, and intending purchasers should consider very carefully the merits claimed by these agents for their particular machine.

Thin cream contains a large amount of skim-milk which is valuable to the farmer for feeding purposes. It requires more water and ice for cooling, and in it the conditions are more favorable for the rapid development of lactic acid and bad flavors. The cost of delivering the cream at the creamery is greater on account of the larger quantity. The butter-maker has to supply extra vat room, and it is more difficult to get good results in churning.

When milk is set for cream to rise either in shallow pans or deep cans, the force of gravity compels the heavier portion to go to the bottom, and the cream being lighter rises to the top, and is separated more or less perfectly from the skim-milk. But when milk is delivered into a rapidly revolving separator bowl, the centrifugal force acts with much greater intensity. Separation takes place almost instantly and is much more perfect.

The hand separator has many advantages over the shallow pan and deep setting methods of creaming milk, and its disadvantages are comparatively few.

Some of the advantages are:

1. The loss of fat in the skim-milk is reduced to a minimum.

3. It saves the cost of utensils and the space required for their accommodation.

3. It gives a better and more uniform quality of cream and butter.

4. The richness of the cream can be easily regulated.

5. It saves labor in washing utensils and in the handling of ice for cooling purposes.

6. The skim-milk is in the best possible condition for feeding young stock.

The chief objections to the hand separator are its first cost and the labor of turning and washing the machine; but when we consider that the increased product made from the saving in loss of fat in skim-milk alone, over the best of other methods of creaming, to say nothing of its other advantages, amounts to from five to ten dollars per year for each cow, it will be seen that the separator will soon pay for itself. The labor of washing the machine is also a small consideration when compared with the labor of washing the utensils required for either the shallow pan or deep-setting methods.

The cost of a hand separator is from $50 to $150, according to the size and capacity, and they will skim from 150 to 700 pounds of milk per hour. A separator having a capacity of 450 pounds per hour is of sufficient size where from eight to ten cows are kept.

In choosing a separator it is advisable to select one with a capacity somewhat larger than is required for immediate use. The feed tap may then be slightly closed, and the skimming done with the separator running a little below its capacity. This makes a favorable condition for the separator to do close skimming, and also for the production of a rich cream which is so desirable at the present time. All, except the smallest sized machines, are so constructed that they may be connected with power and much labor may be saved in this way. The most common power in use is the tread power. It may be run by any farm animal with good satisfaction. A small gasoline engine is also a very efficient power where the separating room can be placed at a suitable distance from the barn, to avoid any possible danger of fire. There is also danger of tainting the cream from the odor of the gasoline.

There are many different makes of separators on the market at the present time, but which is the best it is impossible to say, as no one separator comprises within itself all the points of merit that the ideal might possess. The best separators might be described as those best suited to the special conditions under which they are to be used. It may be that the less capable of two separators is the better, for the reason that it may have advantages and conveniences which at first might seem of little importance, yet be of great value in the peculiar circumstances under which it is to be used. For example, the closest skimming separator may be more difficult to operate, more inconvenient to clean, or possess other disadvantages in its mechanism less desirable than a machine which skims less closely, and these diadvantages may more than counterbalance its closer skimming power. A hand separator may be considered to be doing good work, when, running at its full capacity, it will produce a cream testing over 30 per cent. fat, and leave not more than one-tenth of a per cent. (.1) of fat in the skim-milk, or a reading not extending over one space, in the graduated neck of a skim-milk test bottle.

The points of merit which a separator should possess are:

1. Simplicity and strength of construction.
2. Cheapness and durability.
3. Maximum capacity with minimum power required to turn.
4. Closeness of separation.
5. Desirable richness of cream.
6. Ease of cleaning.

With each separator is sent a book containing full directions for setting up, and operating the machine. This should be carefully read before removing the machine from the box. A suitable place for setting it up should then be chosen, care being taken to select one that is well ventilated, and where a pure atmosphere can at all times be assured. It is most convenient to have the separator in the barn, as it saves the labor of carrying the milk to the house and the skim-milk back to the barn, but the practice of allowing it to occupy a stall in the stable is very objectionable, on account of the injurious effect on the flavor of the cream, and injury to the machine due to dust and dirt getting into the bearings.

The frame should be fastened securely to a solid foundation, and the part of the frame containing the bowl should be perfectly level on top in all directions. A small quantity of quarter inch rubber packing, placed under the outside edge of the base or under the legs before fastening, improves the running of any separator.

Before the separator is started all parts should be thoroughly cleaned and all bearings well oiled. The oil-cups and oil-holes should be in good working condition. Special attention ought to be given to the oil that is used. When convenient, it is advisable to use the oil sold by the agent of the machine, but if not, any good separator oil will do. It should be rather thin, so as to give a clean drop, and be free from any tendency to gumminess when exposed to a very low temperature. It is a good practice to flush the bearings and oil-holes with coal oil once every week or ten days. This removes the thick oil and grit and adds greatly to the easy running of the machine.

Two or three minutes should be taken to get the speed up to the required rate which is usually stated on the crank of the machine. Sufficient water, at a temperature of about 110 degrees, should be added to to fill the bowl, to wet and warm the surface and prevent the cream from sticking. The milk should then be turned on full flow, and the feed pan kept well filled until the milk is all in. The speed should be kept well up, and as uniform as possible at all times to insure closeness of skimming and an even richness of cream.

In the use of a separator three things should be carefully watched, viz., the speed of the bowl, the temperature of the milk, and the feed of the milk to the bowl. With the same machine, and all other conditions the same, the greater loss of fat must be expected when the separator is not run up to the required speed, or when the milk is below a certain temperature, or when more than a certain amount of milk is run through in a given time.

Milk separates best when fresh or new, and at a temperature of 90 to 100 degrees F. Tests made with different hand separators with milk at temperatures below 80 degrees showed, in every case, a much greater loss of fat in the skim-milk, than when similar milk was separated at a temperature over 95 degrees F. Therefore, if for any reason, the milk has been allowed to cool below 85 degrees it should be heated again before separating if close skimming is desired. When the milk is all run through, the cream should be flushed from the bowl with a little warm water or skim-milk. The power may then be removed and the speed allowed to run down of its own accord. The bowl should not be stopped by applying a brake of any kind, unless provided by the manufacturer, as it injures the bearing and shortens the usefulness of the machine. All parts of the separator should then be thoroughly washed, first in tepid water, and afterwards scalded, then placed in a pure dry atmosphere until required for further use.

The richness of the cream may be regulated by the adjustment on the machine which will be either a cream, or a skim-milk screw. If the adjustment is by means of a cream screw, the cream may be made richer by turning the cream outlet towards the centre of the bowl, and thinner by turning it away from the centre or towards the outside.

In the case of adjustment by means of a skim-milk screw, the directions would be the reverse.

Other conditions which influence the richness of the cream are the speed of the bowl, and flow of milk into the bowl, and, to a certain extent, the temperature of the milk. High speed and a low feed give a rich cream, while a low speed with a regular or increased amount of feed will give a thin cream, and probably this accounts for the great variation in the cream tests from the same machine.

A low speed with a full feed of milk makes a very unfavorable condition for a separator to do good work, and should not be used as a means of lowering the test, as it is usually associated with a high loss of fat in the skim-milk.

The care of the cream is by no means the least important part of the work. As soon as the separating is completed the cream should be cooled immediately to as low a temperature as possible in the summer and to a temperature below 60 degrees in the winter. When different lots of cream are to be mixed, the fresh cream should always be thoroughly cooled before it is put in with the old cream. Adding fresh warm cream to cream that has been separated and held for some time causes the development of lactic acid, which, if not properly controlled, will cause bad flavors in the cream and butter.

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## FARM BUTTER MAKING.

By Miss Laura Rose.

Every year less butter is being manufactured on the farm; and this is as it should be, for while I teach home-dairying, still I am a great advocate of co-operative dairying.

Good butter can be and is made on the farm, but from lack of skill, care, or improper surroundings or utensils, dairy butter very often lacks the fine flavor and body found in a No. 1 quality.

As civilization advances, conditions multiply. In a new country the milk and butter is apt to be better than that produced in a thickly settled district. This is owing to bacteria of an objectionable nature being less prevalent and as a result milk and its products are not so liable to contamination.

Cleanliness from the very start to the finish is the great essential in the art of making good butter, and too much stress cannot be laid upon its importance.

## The Cow.

Farmers are far too well satisfied with the cows they keep. Were they their hired help they would not give them shelter another night. They would let them go for the simple reason that they did not earn their bread, let alone showing the smallest profit. We must, if we wish to make dairying pay, increase and improve the milk. A cow that is well fed and cared for should produce 6,000 pounds of milk containing 3.6 per cent. butter fat, or should make 250 pounds of butter per year. I would urge farmers to weigh the milk from each cow at least one day every month and test it for butter fat. This is the only accurate way of making comparisons and finding out what the herd is doing individually. The cow stable should be well lighted, well ventilated, and kept clean. Give the cows plenty of wholesome food. It is the poorest economy to stint the cows either in the matter of food or water. Also see that salt is always accessible to the cattle.

## Milking.

There is no nicer place to milk cows than in a well-kept stable. Milk quietly, quickly, cleanly, and thoroughly. Cows do not like unnecessary noise or delay. Commence milking at the same hour night and morning, and milk the cows in the same order. Wipe the cow's flank and udder to prevent loose dirt and hairs falling into the milk. Do not wet the hands with milk. A practice to be recommended is rubbing a little vaseline on the hands. This keeps the teats in nice condition and overcomes the objection some have of milking with dry hands. Nothing tends more readily to drying up the milk flow than leaving a little milk in the udder.

## Straining the Milk.

Remove the milk as soon as possible from the stable, and immediately strain through several thicknesses of cheese cloth. Place the cheese cloth over the bottom of the strainer, and secure it with an easily fitting tin hoop. The cloth must be removed and well washed after each time of using.

## Creaming the Milk.

Shallow Pans. This method is the oldest, and is still used when but a few cows are kept or when ice cannot be secured or the supply has become exhausted. Tests of the skim-milk show that when the milk has been properly set and skimmed, the loss of butter-fat is no greater from the shallow pans than from creamers. The milk should be set in clean, bright tins, and should not exceed three inches in depth. It is most necessary that the milk room be clean and free from all odors, as milk so readily absorbs any taint that may be in the atmosphere. The temperature should range between 50 and 60 degrees. Avoid having the milk close to the wall or in a strong draught, so as not to have a leathery coat form over the cream, due to rapid evaporation. Skim before the milk thickens. Loosen, with a thin bladed knife, the cream from the sides of the pan. Lift the pan to the edge of the cream can, tilt it to allow a little of the skim milk to wet the edge of the pan, then with the aid of the knife, quickly glide the sheet of cream into the cream can.

Dilution System. Many devices have been put on the market for creaming milk by adding a certain percentage of cold water. We have tried several, and do not recommend any. There is danger of contaminating the cream by using impure water. It robs the cream of its flavor, and besides the loss of butter fat is usually heavier than when the deep cans are used. The skim-milk is too much diluted for feeding purposes.

Creamer. If the cream is raised by the deep setting system, the cans should be placed immediately in water the depth of the milk and the milk brought as soon as possible to 45 degrees or below, and held at that temperature. *Use plenty of ice.* It is economy to have ice always in the water, and just as necessary to use it in the winter as in summer. A water-tight box or barrel will do as effective work as an expensive cabinet creamer. We prefer a slant-bottom can, with a tap to draw off the milk. Having the slant carries away any sediment and permits all the skim-milk to be drawn off.

Cans without a tap should be skimmed with a funnel-shaped dipper, having a long straight handle and no wire around the rim. With a knife loosen the cream from the sides of the can, then wet the dipper in water or milk and lower, point first, into the can, allowing the cream to flow evenly into the dipper. Repeat until all the cream is removed. Avoid getting too much skim-milk with the cream.

Milk should always set twenty-four hours before the skim-milk is drawn off, and thirty-six hours in winter is even better. Milk allowed to stand only twelve hours before skimming will give a cream testing from 16 to 18 per cent. butter fat, while the skim-milk will test as high as from .6 to 1 per cent. Cream from milk allowed to stand twenty-four hours will test test from 18 to 22 per cent. butter fat, and the skim-milk from .25 to .35 per cent., or in other words we have in the latter case a richer cream and less loss in the skim-milk—two desirable conditions in the creaming of milk.

Cream Separators. A separate article in this bulletin is devoted to the hand separators; otherwise, much might be said in favor of this method of creaming milk. It certainly is the ideal way of obtaining the cream. A separator, even with only a small herd, pays, for it should mean less labor, better cream, and more of it.

## Care and Ripening of Cream.

During the collection of cream for a churning, the cream can should stand in the coolest place in the cellar in summer, while in the winter it may be kept in a room where the temperature ranges between 50 and 60 degrees. The surrounding atmosphere should be clean and sweet. The can must always be covered. Have a tin stirrer which reaches to the bottom of the can and stir thoroughly, from the bottom to the top every time fresh cream is added.

Each time the can is emptied it should be well washed, scalded and put in the sunshine for several hours. In order to be able to do this, it is a good plan to have two cream cans.

When beginning to collect cream for a churning, add to your first skimming a culture or starter which you know has a clean, pleasant, sharp acid flavor and smell. This culture may consist of a pint or two of sour cream from your previous churning or the same amount of good-flavored skim-milk. The reason for adding the culture is that the bacteria which you know produces a fine flavored butter may take possession of the new cream before other germs which might prove objectionable gain control of it.

Another method is to hold the cream sweet until twenty-four hours before churning, then heat it to 65 degrees and add one pint of culture to every gallon of cream. In the evening cool to churning temperature or below, and hold at that temperature over night.

Separator cream should have the foam well stirred in, and by placing in cold water, should be quickly cooled to 60 degrees in winter and from 50 degrees to 55 degrees in summer. Stir the cream occasionally while cooling. It is most essential that this thorough and quick cooling be done before adding the cream to the cream can, otherwise separator cream cannot make choice butter.

Examine the cream, and when it has a smooth, glossy appearance, pours like molasses and has a pleasant acid taste and smell, it is in proper condition to churn. Churning should be done not less than twice a week in summer and three times in two weeks in winter.

To insure a good body in the butter have the cream lowered to churning temperature or below several hours previous to churning. It does no injury to raise the temperature to that desired, but when the temperature of the cream is lowered just before churning, the fat globules have not had time to harden and the result will be a soft, weak-textured butter.

To prevent loss of butter fat in the butter-milk, sweet cream should not be added during the last twelve hours before churning.

Perfectly sweet cream will churn in the same time as ripened cream and makes a mild creamy-flavored butter which is gaining in favor in the best markets. If the temperature of sweet cream is kept low, there is no excessive loss of butter in the butter-milk.

Complaints are sometimes made about a bitter flavor in cream. When held sweet for some time at a very low temperature this bitterness frequently develops. To overcome this difficulty, either pasteurize or get the cream started to sour.

For farm buttermaking we do not consider pasteurizing the cream necessary, but if bad flavors are found in the sweet cream it will to a great extent destroy them. To pasteurize, place the can holding the cream in a dish of hot water on the stove, and bring the cream to 160 degrees, and keep at that temperature for twenty minutes; then quickly cool to about 60 degrees. It is always necessary to add a culture to pasteurized cream if you wish to ripen it.

## The Care of the Churn.

Before using, the churn should be scalded with boiling water and afterward rinsed with cold water. It is better and quicker to pour the water out than let it run through the bung hole. Floating dust will not then cling to the sides of the churn. After using, the churn should be rinsed down with hot water, thoroughly scalded with boiling water, then given a scouring with salt, followed by another rinsing with hot water. Wipe the outside, but do not touch the inside with a cloth. Never allow butter-milk or wash water to remain in the churn when not in use. Leave the plug out and the lid ajar, and keep in a cool place to prevent warping.

The worker, ladles, and butter-print may be prepared while the butter is draining. With a fibre brush, a dipper of water, and a little salt, give them a good scouring and cool well with cold water. After using remove any butter with hot water, again scour with salt, rinse with boiling water, and allow them to dry.

## Churning.

Always strain the cream into the churn through a dipper with a perforated tin bottom. In winter add just sufficient butter color of a reliable brand to give a nice yellow tint. Do not depend on pouring it in, but count the drops for a small churning, allowing 3 or 4 drops to the pound of butter.

No definite temperature for churning can be given, but the necessity for the constant use of a thermometer must be emphasized.

Many conditions influence the temperature of the cream for churning such as the richness of the cream; the quantity in the churn; the feed and breed of the cow; the length of time the cows have been milking; the temperature of the room; and the speed of the churn. Aim to make conditions favorable to a low churning temperature as it insures a better butter and a more exhaustive churning.

Start with the churn about one-third full, which means not more than five gallons in a No. 3 churn, and regulate the churning temperature so as to have butter within from 20 to 30 minutes. That proper temperature can only be ascertained by past experience with similar cream.

I would suggest a range of temperatures for summer from 54 to 58 degrees and in winter from 58 to 64 degrees.

Cream that contains too much skim-milk and is too cold will foam. Never add hot water to the cream. It must be taken from the churn and heated by placing the can in a pan of hot water and stirring until the desired temperature is reached.

Poor cream often breaks but will not gather. Try churning slowly. If this does not overcome the difficulty the only remedy is to draw off part of the buttermilk to lessen the liquid.

Very rich cream is likely to paste or thicken in the churn, so that concussion ceases. Add enough water at the same temperature as the cream to dilute it so that it will drop.

When the churning is about completed, add a couple of quarts of water several degrees lower in temperature than the cream was. In the summer it may be quite cold. This floats the butter and allows the buttermilk to run off more freely. When the butter is the size of wheat grains it is sufficiently gathered. Look frequently at the inside of the churn lid, and when but few small specks are seen on it, the churning is usually finished. Watch the buttermilk as it runs through the strainer dipper, and if any butter comes with the first streams, a little more churning is necessary.

### Washing the Butter.

When the buttermilk is drawn, rinse the butter with a little water and strain through cheese cloth into the churn as much water as there was cream. Temper the water in winter, having it from 48 to 56 degrees according to the conditions of the butter and the temperature of the room. In hot weather the wash water may be as cold as possible. Revolve the churn rapidly about a dozen times, and wash but once. We recommend washing butter twice if it has come very soft or has an objectionable flavor, or is going to be packed for winter use.

### Salting the Butter.

Salt according to the demand of the market. If the butter is for immediate use and is salted on the worker 3-4 ounce per pound of butter is usually sufficient. If salting in the churn use an ounce, as not so much is incorporated in the butter. We strongly recommend salting in the churn, as by so doing butter free from streaks can be had with the least possible amount of working, but the churn must be without dashers, and the butter in firm granular form. The only difficulty in this method is gauging the amount of salt. Estimate the weight of butter from the last churning, then weigh the salt. Have the butter evenly spread over the bottom of the churn, sift on part of the salt, tilt the churn forward to cause the butter to lap over, sift on more salt, then tilt the churn backward and put on the remainder of the salt. Put on the lid and revolve the churn very slowly until the butter forms in several lumps. It may be taken out and immediately worked, but if possible it is much better to allow it to stand either in the churn or in a firkin, if the churn is in too warm a place, for two or three hours, and then give one working.

If salting on the worker, take the butter from the churn, weigh it, and allow $\frac{3}{4}$ ounce of salt per pound of butter. Spread the butter over the worker, sift the salt on evenly, fold the salt under and begin working.

## Working the Butter.

For the farm dairy there is nothing nicer than the V-shaped lever butter-worker. It is not expensive and is a great saver of time and strength, besides preserving the grain of the butter.

Work by means of pressure only; avoid a sliding motion as it makes a greasy, salvy butter. Work sufficiently to expel the moisture and thoroughly distribute the salt. Any portion of the butter not reached by the salt will be light in color.

If the butter is very soft or very hard, work but slightly, allow it to stand and when at the proper firmness, give it a second working.

## Printing the Butter.

The brick-shaped pound print is the most popular form in which to market butter. Finish the butter smoothly and press the print down into the butter until the mould is well filled. Cut with a ladle the surplus butter from the bottom. Wrap the print neatly in good parchment paper, which has been previously wet in clear, cold water. It is a good plan to have the paper stamped with the name of the farm or butter-maker. It is often the means of securing a choice trade. Be sure the print weighs a full pound or slightly over. The butter when wrapped in the wet paper should weigh full 16¼ ounces.

Keep the butter in a cool clean place and get it to the consumer as soon as possible.

## Packed Butter.

When the butter is to be kept for winter use we advocate pasteurizing the cream and seeing that in every respect it is of No. 1 quality. Wash twice and salt heavier. Either allow it to stand in the churn for several hours after salting, or give it two workings. Pack in well glazed, thoroughly-scalded crocks; finish off to within ½ inch of the top. Cover with parchment paper and with a layer of moistened salt. Tie down with paper, and keep in a dark, cool place. If the salt on top dries, add water to it. It is better to keep the butter frozen if possible.

## The Milk Pails and Pans.

Clean all tin dairy utensils by first rinsing in warm water, then clean inside and out with a brush and hot water in which a cleansing material such as washing soda is dissolved. Lastly rinse with plenty of boiling water and leave inverted in pure air and sunshine, when available, until wanted for use.

## Applied Proverbs.

Praise the day at eventide, and the cow at the end of the year, if she then deserves it.

Children are the riches of the poor; but if you get them interested in the dairy they will help lift the mortgage from the farm.

The shoe knows whether the stocking has holes; the tarmer *should know* where the leaks are that rob him of the profits from his dairy, and should set about mending them.

Cleanliness is next to godliness; this applies as much to the *cow stable* as to the *front parlor.*

It is hard for an empty sack to stand straight; but still harder for a lazy man to succeed in the dairy business.

We'll take the good will for the deed. Did you ever hear the cows say that when you neglected to properly feed and water them?

Penny wise and pound foolish is the woman who still uses old-fashioned, out-of-date dairy utensils.

'Tis good in every case you know
To have two strings unto your bow;
Some clucking hens and a brooding sow
Increase the profits from the dairy cow.

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ONTARIO AGRICULTURAL COLLEGE

BULLETIN 144

# Apple Culture

By

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Professor of Horticulture

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Ontario Agricultural College and Experimental Farm,

# APPLE CULTURE.

By H. L. Hutt, Professor of Horticulture.

One of our leading nurserymen has observed that the demand for nursery stock of any particular kind of fruit depends largely upon the crop and the prices realized for that fruit the peceding season. If, for instance, apples are a good crop and bring good prices, the next year there will be a great demand for apple trees, but if the crop happens to be a failure or prices are unsatisfactory, many are then ready to tear out their newly planted apple trees and plant whatever fruit seems to be paying best at the time. The folly of such a shortsighted policy need hardly been commented upon. The planting of an apple orchard is an investment which lasts for more than a life time. It is wise, therefore, at the beginning to take a broad outlook and determine upon some definite line of work, and then adhere to it steadily. We can point to numerous apple growers throughout the Province who have made money out of their orchards, but these men did not lose faith, nor neglect their trees, when the crop was a failure or the prices low.

No doubt many growers have been discouraged by the low prices obtained for the fruit in some seasons, yet in most cases it might have been found that this was due largely to the unbusiness-like methods employed in handling and marketing the crop. The outlook for the apple grower never was brighter than at the present. With the reliable information we now have regarding varieties; more rational methods of caring for the trees; improved methods of handling the crop; and local and national co-operation in marketing it, there is no doubt that the apple crop will prove to be one of the paying crops of the future. There is a constant demand for first-class fruit in the best markets of Europe. Then if we realize for a moment the rapidity with which the great North-west is being settled, and consider that in all likelihood the apple will never be successfully grown in that latitude, we may safely count upon the North-west as one of the promising, and ever-increasing markets. In view of these facts, we believe that the Ontario farmer and fruit-grower, who is favorably located for the production of apples, can make no mistake in planting apple trees,—to what extent being determined mainly by the amount of care and attention he is certain of being able to give them.

Apart from the commercial side of apple culture, there is still need for the planting of small orchards on farms throughout the country for home use. It is surprising to find even in good fruit growing districts, such as we have in the greater part of Ontario, that there are yet thous-

NOTE. In the preparation of this bulletin Professor Hutt was assisted by Mr. H. S. Peart, B.B.A., Demonstrator in Horticulture. The section on "Insects Injurious to the Apple" was prepared by Professor W. Lochhead, Professor of Biology.

ands of farms upon which there is not an apple tree growing. The apple is certainly one of the most useful of all fruits, and no one who has a farm can afford to be without a small section devoted to apple trees for home supply.

## Selection of Varieties.

One of the most important things to be considered in planting an orchard is the selection of varieties. Some of the most serious mistakes in the past have been made in this particular. In many cases worthless varieties have ben planted, which is hardly to be wondered at when planters had little more to rely upon regarding varieties than the exaggerated descriptions given by travelling tree agents. But in these days when we have reliable information about all classes of fruits for all sections of the Province published annually and distributed free, as is done in the report of the Ontario Fruit Experiment Stations, there is no excuse for planting anything but the very best varieties suited to each section.

One mistake to be avoided is that of planting too many varieties, particularly in commercial orchards. A half dozen good winter sorts has been found to be plenty. For home use, however, the list might be doubled, or at least lengthened, to suit the preferences of all members of the family. There should, in any case, be varieties enough to cover the season and give a bountiful supply from earliest to the latest. One or two summer varieties, three or four autumn, and half a dozen winter varieties would be about the right proportion of each to plant.

Another precaution which has to be taken in planning a commercial orchard, is that of planting too large a block of any one variety. For convenience in harvesting it is no doubt best to plant trees of the same variety near together, but on the other hand if these blocks of one variety are too large it may be the cause of poor crops, for there are many varieties which are self-sterile, that is, the pollen which they produce will not properly fertilize their own flowers, although it may be quite potent on the blossom of some other variety. This question has not been sufficiently studied to warrant us in saying definitely just which varieties are self-sterile and which are self-fertile, although from experiments which have been made, the following varieties appeared to be more or less self-sterile : Yellow Bellflower, Chenango, Gravenstein, King, Northern Spy, Primate, Rambo, Red Astrachan, Roxbury, Russett, Golden Russet, Spitzenburg, and Tolman Sweet. None of these should be planted in blocks of more than three or four rows, without some other variety intervening which blooms about the same time. In orchards where such a mistake has been made, it can be rectified most readily by grafting every third or fourth row with some variety which will insure cross-fertilization.

Both tree and fruit must be considered in the selection of varieties. The tree must have sufficient hardiness for the locality, and it is in this particular that the Fruit Experiment Stations give valuable information to intending planters. Productiveness is also an important characteristic. Unfortunately some of the varieties of most excellent quality, such as the Blenheim and King are lacking in this respect, and, while it may be desirable to plant these for home use, still such a defect is a serious one in a commercial orchard. The age of bearing is another characteristic which varies greatly in different varieties. The Northern Spy, for instance, often requires ten to fiften years before it comes in bearing, while Ontario, Wealthy, and many of the Russian varieties sometimes bear even in the nursery rows, or at least in a year or two after they are transplanted into the orchard. This is a difference which may well be taken advantage of in the arrangement of varieties in the orchard, for, as a rule, those which are slow in coming into bearing make larger trees and are longer lived, while those which begin early and bear heavily are more or less dwarfed in their growth and the trees are shorter lived. For this reason trees of the precocious varieties are often planted as fillers between rows of the later bearing and larger growing kinds.

The most desirable qualities in the fruit itself depend largely upon whether it is for the market or for home use. For home use, good quality is the first consideration. Usually those having a spicy or characteristic flavor, such as the Spy, King, or McIntosh, are most desirable. Apples with an acid or subacid flavor are most in demand on the market; nevertheless a good sweet apple is often much appreciated for home use. For the market, good appearance is the first consideration. No doubt in time buyers will be more discriminating and demand good quality rather than fine appearance, but at present the most saleable apples are those that keep well, are of fair size and an attractive color. Well colored red apples are those in the greatest demand in the Old Country market, a point which should be remembered in selecting varieties intended for export. Good shipping qualities have also to be considered in the selection of commercial varieties, although no doubt the improvement in methods of packing and shipping may render this of less importance in the future than it has been in the past. The Ben Davis apple has long been recognized as one of the best shipping varieties, on account of its firmness and good keeping qualities. On the other hand, the McIntosh is not a long keeper and is so easily bruised that it cannot be shipped satisfactorily in barrels. But with improved methods of packing and shipping, it may be shipped to any of the European markets and even placed on sale with the Ben Davis, and it is a question how long the Ben Davis, with its inferior quality, will be able in such competition to hold its place in the market. Those who champion the Ben Davis may take exception to the comparison just made because of the relative difference in season of the two varieties. Nevertheless, we believe that it will be safer in the future for growers to look more to the quality of the variety than has been done in the past, for in due time buyers will no doubt become more discriminating and demand apples of the very best quality.

## Varieties Recommended to Ontario Planters.

The following list, prepared by the Board of Control of the Ontario Fruit Experiment Stations, contains only a few of the most valuable varieties recommended for planting in Ontario. These have been selected from about 800 that have already been tested in this Province. This list might well be doubled to include a number of valuable kinds for special localities.

In the following lists the varieties are mentioned in their order of ripening. The division into summer, autumn, and winter varieties is an indefinite classification because of the marked difference in the season of maturing in northern and southern sections of the Province, yet, it is valuable to some extent as a guide.

### Varieties Valuable for Market.

#### Summer.

Red Astrachan : Adapted to all sections except the extreme north.
Duchess : Adapted to all sections.

#### Fall.

Gravenstein : Adapted to all sections except the St. Lawrence River district and the more northerly portions of the Province.

Wealthy : Particularly valuable for northern sections.

Alexander : For northern sections.

McIntosh : Adapted especially to the St. Lawrence River district but can be grown over a much wider area.

Fameuse : Adapted especially to the St. Lawrence River district, but succeeds well over a much wider area.

Blenheim : Adapted to all sections except the St. Lawrence River district and the more northerly portions of the Province.

#### Winter.

King : Adapted only to the best apple sections, and succeeds best when top grafted on hardy stocks.

Hubbardston : Adapted to the best apple sections.

Greening : Adapted to the best apple sections.

Cranberry : Requires good soil and is adapted to the best apple districts, but especially southern Ontario.

Baldwin : Succeeds best on clay land, and is adapted to the best apple districts.

Northern Spy : Adapted to the best apple districts, but can be grown with success further north by top grafting on hardy stocks. This is also a good method of bringing it into early bearing.

ONTARIO : An early and abundant bearer, but short lived. Recommended as a filler among longer lived trees. Adapted to same districts as Northern Spy, which it somewhat resembles.
STARK : Adapted to best apple districts.

### VARIETIES VALUABLE FOR HOME USE.

#### Summer.

YELLOW TRANSPARENT : Adapted to all sections.
PRIMATE : Adapted to best apple sections.
SWEET BOUGH : Adapted to best apple sections.
DUCHESS : Adapted to all sections.

#### Fall.

CHENANGO : Adapted to best apple sections.
GRAVENSTEIN : Adapted to best apple sections.
WEALTHY : Especially adapted to northerly sections.
McINTOSH : Especially adapted to northerly sections.
FAMEUSE : Especially adapted to northerly sections.
BLENHEIM : Adapted to best apple sections.

#### Winter.

KING : Adapted to best apple sections. Should be top grafted.
WAGENER : Adapted to best apple sections.
SWAYZIE POMME GRISE : Adapted to all sections except most northerly.
GREENING : Adapted to best apple sections.
TALMAN SWEET : Adapted to best apple districts.
NORTHERN SPY : Adapted to best apple districts, but will succeed farther north if top grafted.
MANN : Adapted to best apple districts, but will succeed farther north if top grafted.

### HARDY VARIETIES RECOMMENDED FOR SECTIONS NORTH OF LATITUDE 46 DEGREES.

Summer : Yellow Transparent, Charlamoff.
Fall and Winter : Duchess, Wealthy, Hibernal, Longfield, Patten's Greening, Whitney Crab, Hyslop Crab.

### LOCATION AND SITE.

The large inland lakes surrounding the southern portion of this Province have a wonderfully ameliorating effect upon the climate for some distance from their shores, and as a rule, our most extensive commercial orchards are in proximity to these large bodies of water. There are, however, in the interior many localities quite as favorable for fruit growing, but in such locations the question of site and exposure has to be more carefully considered. The site usually selected for the orchard is one near the buildings, which may be all right if these are on the highest ground, for such grounds are not only best drained but are least liable to untimely frosts. Good atmospheric drainage is often quite as important as good water drainage, and cold air like cold water runs down hill. Only a few feet of elevation above a wide adjoining area may be sufficient to enable trees in full bloom to escape a frost which destroys the crop on the lower level. On level lands there is practically no atmospheric drainage and the orchardist must take his chances and make the best of it.

## Exposure.

Where the land is rolling, and there is a choice of exposure, the situation should be carefully considered, for in many cases this may be the difference between success and failure. As to which is the best exposure, depends largely upon the surroundings. In proximity to large bodies of water the best exposure is toward the water. In localities subject to late spring frost the safest exposure is toward the north, as this helps to retard the period of bloom till danger of frost is past. On a northern exposure trees are less likely to suffer in times of severe drouth, and there is also not so much injury from sun scald, a most serious trouble in northern localities. For the reasons given a northern or eastern aspect is, as a rule, preferable to a southern or western one, and also because there is less exposure to our strongest prevailing winds, which come from the south west.

## Windbreaks.

Protection from the prevailing winds is another matter that requires due consideration. The shelter accorded by a high hill or natural belt of timber is perhaps the ideal one, but when these do not exist, the planting of a windbreak is necessary. Prof. L. H. Bailey in his excellent book "Principles of Fruit-growing," thoroughly discusses the advantages and disadvantages of windbreaks, and summarizes as follows :

"The benefits derived from windbreaks are the following : Protection from cold; lessening of evaporation from soil and plants; lessening of windfalls; lessening of liability to mechanical injury of trees; retention of snow and leaves; facilitating of labor; protection of blossoms from severe winds; enabling trees to grow more erect; lessening of injury from the drying up of small fruits; retention of sand in certain localities, hastening of maturity of fruits in some cases; encouragement of birds; ornamentation."

"The injuries sustained from wind-breaks are as follows : Preventing the free circulation of warm winds, and consequent exposure to cold; injuries from insects and fungous diseases; injuries from the encroachment of the wind-break itself; increased liability to late spring frosts in rare cases.

"The injury from cold, still air is usually confined to those localities which are directly influenced by large bodies of water, and which are protected by forest belts. It can be avoided by planting thin belts.

"The injury from insects can be averted by spraying with arsenical poisons.

"The injury from the encroachment of the wind-break may be averted, in part at least, by good cultivation, and by planting the fruit simultaneously with the belt. So far as practicable, the wind-break should be planted as a distance of six rods or more from the fruit plantation."

The best trees for wind-breaks are some of the evergreens, such as Norway and White Spruce, the Austrian and Native White Pines. The Norway Spruce is most used because it is a rapid grower, and the young trees may be obtained very cheaply. The wind-break should be planted at the same time as the orchard, it will then be effective by the time the trees come into bearing. A single row may be sufficient, although in very exposed places, a double row, with the trees set alternately, is preferable. The trees should be at least six or eight feet apart, and even ten or twelve feet is better when the trees grow up. The trees in the wind-break should be well cultivated, the same as the trees in the orchard, until they become well established. Neglect of this is the main cause of failure in setting out wind-breaks.

## The Soil and its Preparation.

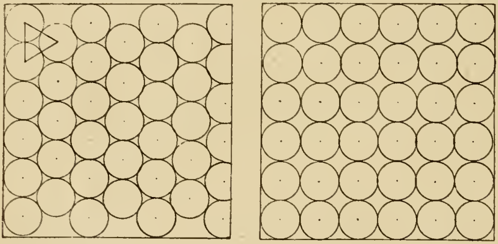
The apple tree readily adapts itself to a great variety of soils, yet there are certain kinds upon which it does much better than others. Light sandy soils are usually deficient in plant food, and are not retentive of it when fertilizers are applied to them. The trees upon such soils may do fairly well for a time, but as a rule they are less productive and shorter lived than on heavier soils. On the other hand, heavy clay soils may contain plenty of plant food, but they are difficult to work and unless very carefully managed bake so hard that the tree will not thrive upon them. The ideal soil is a happy mean between these extremes, a friable loam. It may be called a sandy or a clay loam, as either sand or clay predominates in its composition, and is all the better if of a limestone formation upon an open subsoil.

One of the first requisites in a good orchard soil is good drainage. Fruit trees will not thrive upon undrained soil. If the land is not naturally well drained, it should be thoroughly underdrained.

Good preparation of the soil previous to planting is very essential. Trees set on unprepared soil are seriously handicapped at an important stage of their life and often they never overcome it. Land which has been exhausted by grain growing is in poor condition for the growing of trees, although it may greatly improved by growing and plowing down two or three crops, such as rye, clover, or vetches, as a green manure. Probably no other crop leaves the ground in better mechanical condition for the growth of trees than clover. Its roots penetrate the soil deeply and leave it well filled with vegetable matter or humus.

There has been much diversity of opinion regarding the value of subsoiling in preparing the land for trees. But there is little room for doubt that it is of much benefit on land where the subsoil is hard and impervious to water. The subsoiler should follow in the furrow of the ordinary plow, loosening the subsoil as deeply as possible. Where this is not done, clover roots are the next best thing as subsoilers.

The preparation of the ground for planting should begin by a good deep plowing in the fall, and it would be all the better if it could be ribbed up as is now frequently done in preparing ground in the fall for spring seeding. This insures good surface drainage and quick drying of the ground in the spring. All that would then be required in the spring would be to harrow down the ridges and loosen up the ground as deeply as possible with a spring tooth cultivator.



Hexagonal. Square.

A comparison of the hexagonal and square systems of arranging trees in the orchard.

## Arrangement of Trees in the Orchard.

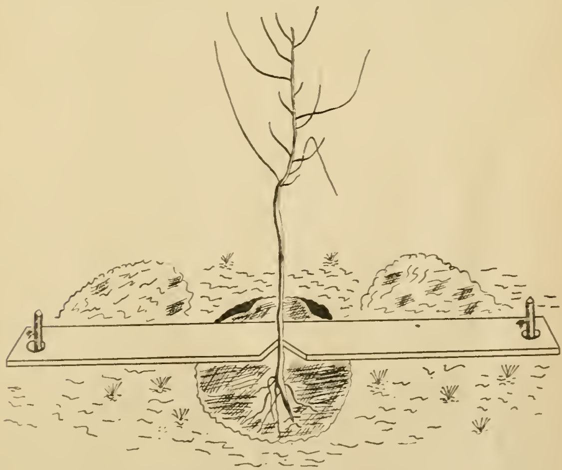
There are several methods of arranging the trees in an orchard. The plan usualy adopted is that known as the square. By this arrangement the rows are planted the same distance apart each way, four adjoining trees forming a square. A more economical plan is what is known as the hexagonal arrangement, which admits of about fifteen per cent. more trees per acre without any more crowding. In the hexagonal arrangement the trees in one row are set alternately with those in the next, six adjacent tres forming a hexagon and enclosing a seventh in the centre.

In laying out an orchard on the square, the first row is staked out at whatever distance the trees are to be apart, and at this same distance, the second and following rows may be staked out in the same manner.

In laying out an orchard on the hexagonal plan, after the first row has been staked at the desired distance, the position of the trees in the second row and also the distance apart of that and the following rows may be most easily found by taking two stout strings or wires, which after being fastened to any two adjacent stakes in the first row, are yet equal in length to the distance apart of these stakes, then drawing the free ends out till they meet, forming an equilateral triangle. This being done at each end of the rows, the intervening trees may be located by measuring.

Whichever method of arrangement is adopted, the trees should be planted in rows as straight as it is possible to set them. Straight rows add not only to the appearance of the orchard, but to the convenience of cultivation. One of the best means of getting the rows straight is to stake out the position for each tree before beginning to plant. Laths are excellent for this purpose. Then when all has been properly staked out, a planting board should be used when planting to insure getting the tree in the exact position marked by the stakes.

A planting board is made of a light piece of board four or five feet long, with a hole bored through each end and a notch in the centre. It is well to have two or three of these made exactly alike, one for the planters and the others for those digging the holes. When a hole is dug, the notch in the planting board is placed around the stake, and wooden pegs are passed through the holes in the end of the board and left in the ground while the hole is dug and the board taken on to the next stake. The planters following place their board over the pegs and the tree in the notch in the centre. It will thus be in exactly the same position as the stake which previously marked the hole.



How the planting board is used.

### Distance Apart for Planting.

The proper distance apart for planting depends altogether upon the ultimate size which the trees may attain, which in turn depends upon the variety, the soil, and the locality. The varieties grown in our most northern orchards seldom spread more than twenty or twenty-five feet. While the kinds grown in the more favored apple sections of Southern Ontario often have a spread of forty feet. The best guides to intending planters is to observe carefully the distances required for full grown apple trees in the neighborhood. In southern Ontario this will be found to be from 35 to 40 feet, throughout central Ontario 30 to 35 feet, while in northern sections where only the hardiest kinds are grown 25 feet will be found quite sufficient. It is wise to allow plenty of space, so that there will be no crowding when the trees have reached their full size. Planting too close is a far more frequent and serious mistake than planting too far apart.

A plan quite frequently adopted, particularly in some of the large American orchards, is to use some of the small-growing early-bearing varieties, as fillers between the large-growing varieties. The Duchess, Ontario, and Ben Davis, for example, being planted alternately with large growing kinds, such as Baldwin, Greening, and Spy.

In such cases the large-growing kinds are set at the maximum distance apart, and the smaller kinds between them. By the time the larger kinds begin crowding, the smaller ones will have paid for their keep and that of the others and can be cut out to make room for the larger trees. The greatest objection to this plan is the danger that the fillers may be left so long before they are removed that the value of the whole orchard may be impaired.

### Ordering and Obtaining Trees.

A complete list of the nurserymen of this Province is published each year in the Report of the Inspector of Fumigation, and most of our leading nurserymen advertise in the agricultural and horticultural papers. Upon application, any of these men are glad to quote prices at which they can supply stock.

It is well, when ordering nursery stock, to order early. Too many leave such a matter till planting time, when they might as well have had their order in several months sooner. By ordering early they are more likely to obtain just what is wanted, and if the nurseyman has not the desired varieties on hand, he can obtain them elsewhere by the time they are needed.

When the trees arrive from the nursery, it is best to unpack them as soon as possible, and, if it is not convenient to plant them at once, the roots should be spread out and buried in a deep trench till they can be permanently planted. The longer the trees are to remain in this position the more carefully they should be heeled in.

### Transplanting.

There is a diversity of opinion as to the best time for transplanting. It may of course be done any time when the tree is dormant, either in the spring or autumn. In favorable localities and with hardy varieties it may be done quite as well one season as another, but for general planting the spring is the safest time in our rigorous climate.

Great care should be taken to prevent the roots of the trees drying while they are out of the ground. If it happens to be hot and windy at the time of transplanting, it is a good plan to puddle the roots in soft mud as soon as they are taken from the packing box or trench, and in carrying the trees about the orchard, it is well to keep the roots covered with a wet blanket or piece of old carpet.

The hole for the tree should be wide enough to hold the roots without cramping or crowding, and should be deep enough to admit of a few inches of fine mellow surface soil being filled in the bottom, and still have the roots an inch or two deeper than they were in the nursery row. The roots should be spread out in their natural position and should be covered with moist mellow surface soil. It is well, in digging the holes, to have the surface soil placed at one side and the subsoil on the other, so that in refilling the surface earth may be placed next the roots and the subsoil left for the top. If the soil has been properly prepared it is seldom necessary to water the roots at the time of transplanting, but care must be taken to ensure the soil moisture from below coming up to the roots. This is insured by tramping the earth firmly as soon as the roots are well covered, and leaving only the top soil untramped to act as a mulch and retain the moisture below. The neglect of this firming of the soil around the roots is one of the most common causes of failure in the transplanting of trees. If watering is necessary, a small pailful poured in as soon as the roots are nearly covered, is of more use than a half dozen on the surface after the planting is done.

All torn, bruised, or injured roots should be cut back, with smooth cuts, to sound wood. Smooth cuts callous over quickly and new roots are the more readily sent out. Trees obtained from the nursery, no matter how carefully they may have taken up, have lost the greater part of their root system, and in order that they may make a satisfactory growth when transplanted the top must also be cut back to a similar extent to restore the balance. This cutting back, however, can be most satisfactorily done after the trees are planted, when they are held firmly by the soil and more careful attention can be given to shaping the head of the young tree.

## Initial Pruning.

Closely associated with the heading back of the top at the initial pruning of the tree, is the question of determining the height at which the head should be formed. On this, as in many other points of orchard management, there is a variety of opinions. Some prefer high heads, because of the greater convenience for cultivation and working underneath; while others prefer them low, because of the greater convenience in pruning, spraying, and harvesting. There are other reasons, however, why low headed trees are preferable; in exposed locations the trees and crop are less likely to suffer from violent winds, and in northern localities the trees with short trunks and low spreading branches are much less subject to injury from sunscald, the most serious tree trouble of the north. At the Algoma Fruit Experiment Station it has been found advisable to start the head not more than a couple of feet from the ground, while in the more favored sections the custom is to have at least four feet of trunk. This is the height at which the head is usually started on two or three year old trees as obtained from the nursery, and for this reason it is better for the northern planter to get two year old, rather than three or four year old, trees, so that he can start the head at whatever height he wishes. In this connection it may be stated that tree trunks do not lengthen, except by pruning off the lower branches, so that at whatever distance from the ground the lower branches are left, that will be the permanent length of the trunk.

Three branches are enough to leave to form the main limbs or framework of the tree top. These should be evenly spaced around the trunk to give a well balanced and symmetrical top, and they should also be placed on the trunk so as to distribute evenly the weight of the top and avoid bad crotches which are liable to split down with weight of crop. It is particularly important at this stage that great care should be taken to train the young tree in the way it should go, and much can be done in training and directing growth by heading back to buds pointing in the direction we wish the new branch to take.

## Cropping and Interplanting.

In a newly-planted orchard the trees occupy but a small portion of the land, and they cannot be expected to give any returns for at least five or six years. It is advisable, therefore, that some other crop be grown in the orchard which will pay for the labor spent upon it till the apple trees come into bearing and require all the space. It is by injudicious cropping, however, that young orchards are often most seriously injured. It should not be forgotten that the apple trees are the first consideration, and that whatever cropping is done in the orchard must not interfere with them in the least.

In some cases the spaces between the trees may be planted with small fruits, such as raspberries, currants, or gooseberries, but these should not be planted within nine or ten feet of the trees, nor should they occupy ground more than six or seven years.

Hoe crops, such as corn, roots, potatoes, etc., have generally been recommended as the best to grow in the orchard, because of the opportunity they afford for cultivation. This may be all right as far as it goes, but these crops draw heavily upon the plant food in the soil and return very little in the way of roots or plant residue. If such crops are successively grown for several years, they are almost sure to seriously deplete the soil of fertility, unless extra care is taken to maintain it by the application of manure or fertilizers. Probably on the whole the least objectionable cropping is a well arranged rotation of crops, in which clover and hoed crops alternate frequently enough to keep the ground in good condition. Some of these crops harbor mice, and whenever such occur in the rotation precautions must be taken at the approach of winter to protect the trees from their ravages.

During all this intercropping a strip must be left in which the trees are growing for regular cultivation, and this strip should be widened each year as the trees increase in size. No cropping should be attempted under the head of the trees, and intercropping should be discontinued as soon as the trees require all the space.

## Cultivation.

It is only during the last decade that the cultivation of the orchard has been considered a problem worthy of special attention by the great majority of Ontario fruit-growers. Even yet many have not abandoned the old practice of leaving the orchard in sod. At nearly every meeting of the farmers and fruit-growers someone asks the question : "Which is the best, sod or clean cultivation with cover crops ?

Cultivation improves the physical condition of the soil by breaking up the soil particles and presenting a greater feeding surface to the roots. By warming and deepening the soil, it permits of a greater depth of feeding area. Every soil particle is surrounded by a thin film of moisture, consequently the finer the soil particles the greater the surface area to hold moisture. A dry earth mulch or dust blanket on top checks the evaporation of moisture from below. Cultivation renders plant food more readily available by promoting nitrification and the decomposition of organic matter in the soil.

Knowing this to be the case, many growers have given the new system a fair trial, and have satisfied themselves that for most sections of Ontario clean cultivation with cover crops is more profitable than sod. There are indeed few cases where sod is more desirable than cultivation; these are where the soil is fertile and contains an abundant supply of moisture.

As soon as possible after the trees are set, a strip on each side should be cultivated to loosen up the soil which has been tramped down during planting. Each year this strip should be widened, so that no crop intended for harvesting is grown beneath the branches of the trees.

Cultivation should begin as early as the ground is dry enough in the spring. The first tool to be used in most cases is the plow. It is well to plow the land about five inches deep during the first few years after setting to encourage deep rooting. As the trees get older the depth of plowing should be gradually lessened, until by the time the orchard is in full bearing three to four inches is sufficient.

It is a good practice to roll each evening what has been plowed during the day, particularly if the ground is inclined to be lumpy. The soil is much more easily pulverized when freshly plowed than if allowed to lie exposed to the weather for several days.

Cultivate with the disc harrow or other cultivator soon after rolling to form a dry earth mulch, which prevents the loss of moisture by evaporation. Subsequently cultivation should be given as soon as possible after every rain, and about every two weeks in dry weather to maintain an effective dust mulch. These latter cultivations may usually be performed by means of light harrows. If weeds and grass get a start, the spring-toothed cultivator with the broad points should be used to cut them off. Cultivation should be continued until about the middle of July or the first of August, by which time the trees should have practically ceased growth. Cultivation after the first of August has a tendency to cause late growth of wood, which will not have time to properly mature and is liable to be killed back during the winter. If trees are making very rapid growth, it may be desirable to cease cultivation even earlier than the middle of July in order to check the growth. At the time of the last cultivation a cover crop should be sown.

## Cover Crops.

What is an orchard cover crop ? It is a crop sown on the ground at that season of the year when trees have ceased their growth. If man makes no effort to cover the ground, nature forms a cover of weeds and grass in her endeavor to protect the soil.

Cover crops may benefit in many ways, of which the following are some of the most important : (1) A cover crop, by adding a large amount of fibre to the land, prevents hard soils from cementing or puddling. (2) On bare and rolling land, where the rains quickly run off and snows blow off the high portions, a growing crop tends to hold these until they have time to soak into the soil. (3) Land covered by a growing crop dries out more quickly in the spring, owing to the transpiration of moisture through the leaves, and consequently may be plowed under earlier in the season than land which is bare. This is a very important point as it enables the orchardist to gain several days in the busy season of spring. (4) Ground covered with vegetation will hold the snows in winter and thus prevent deep freezing, therby avoiding the liability of root killing. (5) A cover crop affords the most economical means of furnishing a supply of humus in the soil. (6) The roots of a cover crop assist the tree roots in rendering available certain mineral plant food in the soil. (7) A large amount of plant food is liberated in the soil after the tree growth has ceased. This is taken up by the growing crop and held in a readily available form for the following season. (8) Leguminous crops, such as clover, vetch, alfalfa, peas, and beans, by virtue of certain bacteria which form nodules on the roots, are able to assimilate nitrogen from the air. As nitrogen is one of the most expensive fertilizing elements, the value of this class of plants cannot be too highly appreciated.

Cover crops should be sown about the middle of July so that they may make a good growth the same season. It is also wise to check the growth of the trees about this time, so that they may mature their wood before winter sets in. The thorough tillage which should have been practised up to this season, leaves the ground in the best possible condition to give the young plants a start. The crop should be plowed under as early in the spring as possible, and cultivation should begin at once. If the crop is large and the soil rather dry, this is imperative, as the large amount of vegetable matter turned under seriously interferes with capillary action and leaves the surface soil unduly dry.

That a cover crop may be of the greatest value, it should be capable of withstanding the winter and continuing its growth next spring. This, however, is not a necessity, as many of the ordinary crops which will not live through the winter are valuable for this purpose.

Different soils require different kinds of crops. This has led to a division of cover crops under several classes. The most important are the nitrogen gatherers, which through the agency of the nodules on the roots can make use of the nitrogen of the air. Such plants as clover, vetches, alfalfa, peas, and beans, belong to this class, and should be used where the soil is deficient in nitrogen. Another class is known as the potash liberators, such as turnips and rape, which, although they do not add anything to the soil, as do the leguminous plants, yet change the form of the mineral potash so that it may be more readily acted upon by the roots of succeeding crops. Then there is a third class, commonly grown, such as rye, oats, and buckwheat, which are valuable chiefly on account of the humus formed by their development.

During the past two seasons, a number of the most common cover crops have been grown in the College orchard with a view to ascertaining their relative values. Among the most promising are the following:

Hairy Vetch, sown at the rate of thirty-five pounds per acre, forms a very close mat over the ground. This is a valuable crop owing to the fact that it collects nitrogen, lies close to the ground so that it does not inconvenience the pickers when gathering the fruit, and also withstands the cold winter and continues its growth early in the spring.

Red Clover and Mammoth Clover, sown at the rate of twenty pounds per acre, are about equal in value, make a fair growth, are low growing, and winter well on drained soil.

Crimson Clover has not made quite as good growth as the red or the mammoth, nor will it stand the winter here, which is a serious disadvantage.

Alfalfa, or lucerne, is one of the best leguminous crops for dry land. It makes a good growth and winters well. There is a mistaken impression that alfalfa will not make sufficient top the first season. Thirty pounds of seed per acre, sown in July, will give a good stand the same season.

Rape has given good results here. It makes a heavy growth of stiff stems, which, although nearly all killed in winter, stand up well enough to hold the snows. Rape can scarcely be recommended for fruiting apple orchards, as it remains wet the greater part of the day, making the work of harvesting very unpleasant. It may be used to good advantage in the rotation, especially if few fruits are to be harvested.

Rye, the favorite crop of many growers, gives a fair amount of top and winters well. One advantage of rye is that it may often be grown on lands not in a physical condition for the growth of clover. In this y be added to the soil, and conditions made more favorable for the growth of clover.

## Maintaining Fertility.

The maintenance of fertility is more frequently neglected in the orchard than on any other part of the farm. Trees, even on poor land, will produce fruit, but it is only on soils where fertility is maintained that paying crops are produced. Each year that fruit is harvested some plant food is removed. If profitable crops are to be expected the supply of plant food in the soil must be maintained.

The most essential elements for the production of fruit are nitrogen, potash, phosphoric acid, and lime. Nitrogen encourages leaf and wood growth, which are essential to the development of the tree and to the production of the best quality of fruit. Potash is an essential constituent in the growth of fruits. It constitutes a large proportion of the ash of the wood and more than 50 per cent. of the ash of the fruit, and is also associated with the development of flavor in the fruit. Phosphoric acid is essential to the development of the tree and the proper ripening of the fruit. Lime is not in itself an essential element, but assists in liberating plant food. On a soil deficient in lime, growth often continues so late that the wood does not mature nor the fruit ripen properly.

Barnyard manure supplies nitrogen, potash, and phosphoric acid, and improves the physical condition of the soil. Cover crops may take the place of barnyard manure to improve the physical condition of the soil, and the leguminous ones may add all the nitrogen required. Concentrated fertilizers or commercial plant foods may be used in conjunction with cover crops to supply all the plant food necessary for the growth of trees. In the use of commercial fertilizers it is well to proceed cautiously, and, by carefully conducted experiments, ascertain what elements of plant food the soil may be deficient in, and what amounts it may be necessary to apply to get the best results. Unleached wood ashes contain a small quantity of phosphoric acid, seldom exceeding 1½ per cent, a larger amount of potash, varying from 5 to 7 per cent., and also a certain amount of lime. Where pure wood ashes can be procured at a price not exceeding ten cents per bushel, they afford an economical source of plant food. An application once in two or three years will usually give excellent results, especially on light soils which are most lacking in potash. Muriate of potash is another economical form in which to obtain potash. Phosphoric acid may be purchased in the form of superphosphate. Nitrogen may be procured in the form of sodium nitrate, but leguminous cover crops furnish a much cheaper source of this essential but costly element.

## Pruning.

The object of pruning is to form a vigorous and evenly balanced tree, which will produce annually a paying crop of good sized, well-colored fruit. Unpruned trees produce many small-sized unsalable apples. Pruning lessens the number of apples per tree, but at the same time increases the size and improves the quality of those produced. A heavy crop of good-sized fruit is not so serious a drain on the vitality of the tree, nor the fertility of the soil, as the same weight of smaller apples would be, for it is the production of the seed which makes the greatest drain on the tree and soil.

Pruning should be practised every year without fail from the time the tree is planted. In this way the operation is never a severe one, and the removal of the large limbs becomes unnecessary. Limbs growing too strongly in any particular direction, which are liable to upset the balance of the tree, should be headed back. Where two limbs cross, one of them should be removed. Branches growing across, from one side to the other, should be cut out. Care should be taken to leave sufficient twigs in the centre to protect from sunscald. Much may be done in directing growth by heading back to a bud pointing in the desired direction. It is while the trees are young that the greatest care in training is required.

A properly pruned apple tree should be open enough to admit sunlight and permit of free circulation of air. Its lower branches should be trained high enough to admit of easy cultivation, yet the top should not be so high that spraying and harvesting are rendered difficult. Varieties differ more or less in their habit of growth, and, while it may be advisable to modify this to some extent, it is not well to attempt to change it unduly. Long bare branches should be avoided, and the formation of fruit spurs should be encouraged on all parts of the tree.

The best time for pruning is just before growth begins. Wounds made at that season soon heal over. It is not well to prune when there is frost in the wood. Pruning while the tree is dormant tends to increase the growth of wood. Summer pruning encourages the formation of fruit buds, but it is not advisable to do much of it, as the removal of any considerable amount of the leaf area tends to check the vigor of the tree. Pruning by the removal of buds may be practised at any season of the year.

The thumb and finger may be used for the removal of sprouts and buds during the summer. A pair of small pruning shears will remove all twigs less than half an inch in diameter. For larger limbs a sharp fine-tooth saw is needed. Make all cuts as smooth as possible and close to the main stem. When a large limb has to be removed, it may be advisable to cut twice, the first some inches out to avoid splitting, and the second to shorten the stub. A common mistake is the leaving of long stubs which cannot heal over before rot begins. Where it is necessary to remove large limbs, the wounds should be covered with grafting wax or thick lead paint to prevent the entrance of spores which cause decay.

## Grafting.

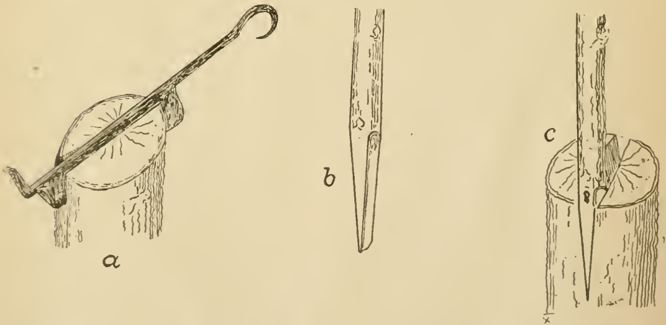
Grafting is the operation of inserting a scion into a stock, usually for the object of changing the variety of fruit produced. Trees bearing undesirable fruit may be top-grafted with some valuable variety. Many choice half-hardy varieties may be successfully grown by top-working on some hardy stock. Especially desirable characteristics in any variety may be perpetuated by grafting. Individuality is quite as marked in plants as in animals. A certain tree may possess some desirable quality, and this may be preserved and perhaps improved upon by selection. It is advisable when cutting scions to select from those trees which have the desirable characteristics most strongly marked. Nurserymen, as a rule, do not pay sufficient attention to the source from which they secure their scions. The individual orchardist may greatly improve his plantation by top-grafting with scions from a tree having the desired qualities most strongly marked.

Grafting is usually performed in the spring. It is essential that the cambium layer of the scion and stock be in contact on at least one side. From this mucilaginous layer, lying between the wood and the bark, the new cells are formed which in time unite the parts and cover the wound. It is necessary to cover the wounds made in outdoor grafting to prevent the entrance of rot-producing spores. For this purpose wax is generally used.

A good grafting wax may be made by melting together four pounds resin, two pounds beeswax, and one pound tallow. Cool by pouring into a tub of water. Then work up into bars or balls which may be kept in any cool place until required. To economize wax, cloth is sometimes dipped into the hot wax, making wax-cloth. This is more difficult to use than pure wax. The wax may be melted and carried in a glue pot and applied with a brush, or as is more commonly done, it may be kept in water warm enough to keep the wax pliable so it may be readily applied by hand. It is well to keep the hands greased to prevent the wax from adhering to the fingers.

There are two common methods of top grafting. Whip or tongue grafting, which is practised upon small branches and young trees. Cleft grafting, which is usually performed on branches from one-half to two inches in diameter.


Whip grafting (a) scion and stock prepared, (b) same placed together, (c) tied.




Cleft grafting (a) splitting the stock, (b) scion, (c) scion inserted in cleft of stock.

In whip grafting the stock is cut with a bevel about one-inch long, and the scion cut to fit that bevel. Both bevels are cut into slightly and the tongue of one fitted into the notch of the other. The cambium layers must be in contact on at least one side. After the scion is set the wound should be covered with wax or similar substance to exclude the air.

Large trees should not be entirely changed over in one year. The first year select the main branches; the second year part of the remainder, and finish the third year. In this way much of the annoyance caused by the growth of water sprouts is avoided.

A handy grafting iron made from a blacksmith's old file.

When cutting off large branches for cleft grafting it is wise to cut twice, making the first cut a few inches above the position chosen for the scion. Then cut off the stub at the desired point, and avoid the danger of tearing the bark. With a chisel or grafting iron split the branch just far enough to admit the scions. Too deep a split weakens the stock, and the scions will not be held sufficiently firm. It is well to avoid grafting two horizontal limbs, one directly above the other. The tendency of new growth is upward, and the growths from the lower one will interfere with the upper. In branches, other than those growing perfectly upright, the split should be made parallel to, rather than at right angles to the ground.

The scion should be made wedge-shaped, with bevel about one inch long, starting at each side just at the base of a bud. Make the scion three buds long, cutting off just above the third bud. It should be cut a little thicker on the side next to the bud, so that the stock may pinch tightly on that side to insure a close contact of the cambium layers.

Open the cleft with the wedge end of the grafting chisel and insert one or two scions, as may be thought necessary. Place the lower bud of the scion to the outside. Do not force the scion down, but open the cleft by enough leverage on the chisel to admit the scion freely. Setting the scion with the top pointing slightly outward insures contact in at least one point. After setting the scions, cover all wounds with wax.

It is sometimes necessary to remove part of the water-sprouts, which usually start during the summer, to give the scions room for proper development. By the following spring the scions should have made sufficient growth to require all space in that part of the tree, and all other growth should be removed.

## SUNSCALD.

Sunscald is an injury to trees which occurs most frequently in the northern districts. It is most serious on young trees, but may also affect the upper side of the large branches in older trees. It is caused by the action of the hot sun on the trunk and branches in the early spring. The first indication is an unhealthy appearance of the bark on the south and southwest sides of trunk and upper side of large branches, the affected parts soon turn brown, then black, and finally die.

In districts where sunscald is apt to occur, it is well to head the trees low and incline the stem slightly to the southwest. In this way the branches afford some shade to the trunk. Anything which will shade the trunk in early spring will prevent the injury. For this purpose the most convenient of the following materials may be used : cornstalks, birchbark, building paper, or a veneer of thin wood, such as is used in basket making. The large branches of old trees should receive natural protection from the small branches and twigs of the top. For this reason severe pruning of the top is not advisable in northern districts.

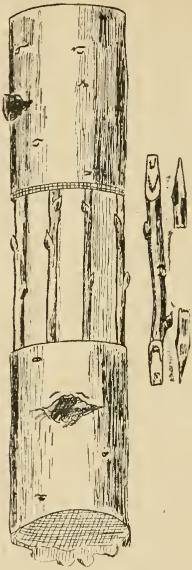
When trees are badly affected they usually die, but where the injury is slight, and is noticed soon after it occurs, treatment is practicable. Cut away the injured parts, and cover the wound with grafting wax or some material which will keep the wood from drying out. If the tree is healthy and vigorous, the annual growth spreading in from the sound parts soon repairs the injury.

## Protection From Mice.

During the past two or three years, mice have become a serious menace to young orchards. The rapid increase in numbers may be largely accounted for by the indiscriminate destruction of the farmer's best friends, the hawks, that feed largely on mice by day, and the owls, which take up the work by night. By carefully protecting the hawks and owls for a few years, their numbers will again increase, so that the equilibrium of nature may be restored. In the meantime something must be done to protect the trees against the rodents.

Mice seldom harbor in a green crop, and on clean fields they find no protection. They are found chiefly along the fence lines and in old meadows. As there is usually some shelter afforded the mice near orchards, it is advisable to guard against their depredations. In localities where the snow falls early and remains on the ground all winter, the simplest means of protecting the trees is to tramp the snow firmly about the base of each tree early in the winter. Where the ground is not continuously covered with snow during the winter, a mound of earth about the tree is sometimes all that is required to divert the runways of the mice. Building paper cut into strips which will reach about one foot high when tied about the trunk of the tree in autumn has been found to be both a cheap and an effective preventive.

## Treatment of Injuries Caused by Mice.



Bridge grafting.

Badly girdled trees usually die. When the part girdled is small and is covered before the wood dries out with grafting wax or other substance, which will protect the inner tissues the tree may be saved. If the girdled part extends entirely around the tree, it will be necessary to establish some connection between the cambium above and below the injury. This may be done by bridge-grafting. For this purpose use long scions cut to a bevel on each end. Insert one end above and the other end below the girdle, making sure that the cut surfaces are in contact with the cambium layer. A sufficient number of these scions should be put in to convey the cambium from the top to the roots and all cut surfaces exposed should be covered with wax.

## Picking.

Apples should be carefully picked by hand, without breaking the skin or bruising the fruit in any way. Summer varieties for immediate home use or special local trade should be allowed to ripen on the tree; but if intended for distant markets or storage they should be picked when fully mature, but before they have commenced to mellow. Winter varieties should hang on the tree until they have reached full size and have taken on good color. Apples picked while still immature as a rule keep longer than if allowed to fully ripen on the tree, but they do not develop the full color nor the best quality. No sharp distinction can be made between green and mature, or between fully mature and over ripe fruit; one blends imperceptibly into the other. Experience teaches at what stage to harvest the crop, in order to secure the highest quality and best keeping properties in the fruit. Sometimes, with summer varieties, it is necessary to go over a tree twice, picking the most mature specimens first and leaving the remainder for a week or two in order that it may more perfectly develop. Round bottom baskets or pails should be used for picking, and it is better to have them lined with cloth to prevent bruising the fruit. Fruit should not be piled on the ground, but should be placed at once on the sorting table or be placed in boxes or barrels for removal to the packing house. The apple should be picked with the stem on but without breaking off the fruit spur, as is likely to occur if the fruit is picked too green. Spring waggons should be used to convey the fruit to and from the packing house.

When the trees have been properly pruned the fruit may all be harvested from ladders. A short step ladder is convenient for the underside and low branches of the tree. For the upper branches light cedar ladders of suitable length will be found very convenient. Extension ladders have been praised very highly in the past, but as they are both awkward and cumbersome, practical growers are abandoning them. The practice of climbing through the tree to gather the fruit, and letting the baskets down to the ground by means of a rope, is out of date, and is not practised in commercial orchards. Inexperienced pickers often lose a great deal of time by not picking clean as they go, making it necessary to carry the ladder back and forth. Each time the ladder is moved all apples in reach should be picked.

## Packages.

A great deal of discussion has taken place during the past few years as to the best style and most suitable size of package. This depends somewhat upon the quality of the fruit and the requirements of the market. For summer varieties for local trade the ordinary eleven quart Climax basket is still the most popular package. For the export trade of XXX apples some prefer the box and others the barrel, depending on the market to be supplied and the relative cost of the two packages. Apples, other than early varieties intended for local markets, can usually be handled most cheaply in barrels.

The adoption of a standard size of box and barrel will have a tendency to establish confidence on the part of the buyer, and will eventually help the apple trade. The Standard barrel is defined in the Dominion Statute entitled Staple Commodities, I. Edward VII., Chap. 26, sec. 4:

"All apples packed in Canada for export for sale by the barrel in closed barrels, shall be packed in good strong barrels of seasoned wood, having dimensions of not less than the following, namely :—twenty-six inches and one-fourth between the heads, inside measure, and a head diameter of seventeen inches, and a middle diameter of eighteen inches and one-half, representing as nearly as possible ninety-six quarts."

The standard box has just been established by the Dominion Government, and its use comes into effect on July 1st, 1906. The inside measurements are: 10 inches deep by 11 inches wide by 20 inches long, having a capacity of 2,200 cubic inches, or very nearly one-third of the standard barrel.

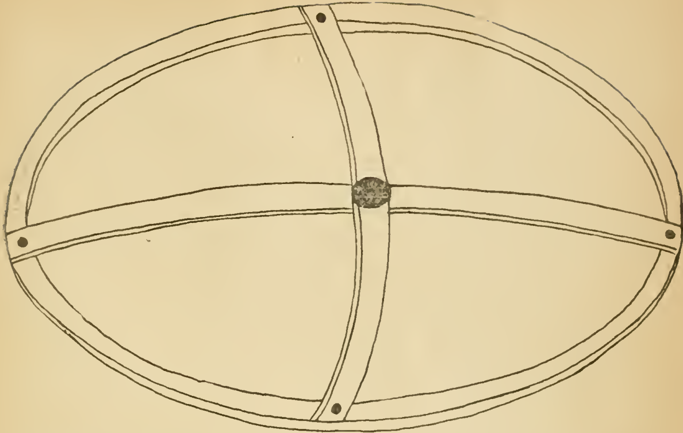
## Grading.

Apples should be carefully graded. Wormy, spotted, bruised, and misshapen specimens should be removed. It is usually well to make two grades of good fruit, differing only in size and color. Each grade should possess uniformity of size and color, and be free from defects. All fruit of one grade cannot be of the same size, but all the fruit contained in one package should be uniform. It is seldom advisable to export anything but XXX fruit, the XX and X fruit may be sold on the local markets or to the evaporators.

Mechanical graders may sometimes be useful in grading to size, but their use is not generally recommended. With a little experience, hand grading soon becomes a very simple operation. A thin board with holes the size of the various grades in which to try an apple occasionally assists in fixing the size in the mind. A basket should be provided for each grade, so that no fruit need be handled the second time.

## Packing.

Apples may be packed in boxes or barrels. If the barrel is used the hoops should be tightened and nailed, the head secured with liners and branded in accordance with the Fruit Marks Act, and the bottom end removed for filling. The first course of apples should be placed in concentric rows with the stems downward. Long stemmed varieties should have the stems clipped out. Some packers recommend placing the second course in by hand, but this is not necessary. The balance of the barrel may be filled by emptying direct from the basket. Be sure to let the basket well down to avoid bruising the fruit. After every two or three baskets the barrel should be racked to settle the fruit into place. To rack a barrel, place it on a plank and rock backward and forward once or twice. When one becomes accustomed to this work it is possible to settle the fruit quickly and effectively. With most varieties the barrel should be filled to about the top of the staves and levelled off evenly. At the last racking, in order to keep the apples from becoming displaced, it is a good practice to place on the top of the fruit, a false head covered with felt. Press the head carefully, tighten the hoops, nail on the liners, and the barrel is ready for market.



An excellent device for pressing the heads in apple barrels. The circle is a little smaller than the head of the barrel, and is made of iron, 1 in. wide and ½ in. thick. The cross bars are made of heavy waggon spring steel. This enables the head to be put in place with the minimum amount of pressure on the head, and avoids bruising the fruit.

Packing in boxes requires more care than packing in barrels. For extra fancy fruit, it is well to line the inside of the box with fancy paper in order to present a better appearance when opened. Excelsior is often used in the top of the box, but it should be covered with paper to prevent the dust from settling among the apples. Place the first course by hand with stem end down. The remainder may be carefully poured in; but for the best results it is better to place all the fruit in layers, making sure that it is packed solidly. Place a piece of heavy paper on top of the fruit, press carefully, and nail the head on. If the fruit is properly packed it should require but little pressing to prevent the fruit from moving. The harder the fruit is pressed the greater the danger of bruising. Brand the box in accordance with the Fruit Marks Act. Always use stencils for branding. Pencil writing on a box is unsightly, and does not give the purchaser as good an impression as neat stenciling.

Some varieties, especially the softer ones, will bring better prices if each apple is wrapped in paper. The paper prevents the fruit from moving and becoming bruised and gives a finished appearance to the case. Only extra fancy fruit will pay for the additional cost of wrapping.

## Marketing.

In so far as commercial fruit growing is concerned, the business end of the enterprise, that of marketing the crop to the best advantage, is second in importance only to that of producing fruit of the best quality.

It is in this particular that there is the greatest need for improvement at the present time; just how the improvement shall be effected is more or less of a vexed question. There are scores of apple growers who have the skill to produce first-class fruit, while there are comparatively few who have the business ability to place it on the market when and where it will bring the best price. This is no doubt an argument in favor of the division and specialization of labor, whereby the grower confines his attention to the production of the fruit and the dealer to the buying and selling of it. But it has been this division of the work among buyers and handlers and sellers that has so divided the proceeds that there has been little or no profit left for the producer. The growers who make the most out of their apples are those who keep in as close touch as possible with the best markets both at home and abroad. During the shipping season these men watch the market reports daily, and unless prices are satisfactory they hold their fruit until good prices prevail. The great majority, however, of those who have apples to sell wait for some local buyer to come along, and sell for whatever he chooses to offer, either so much per barrel or a lump sum for the crop on the trees. The latter plan is little better than gambling, and at best is a hap-hazard way of doing business.

The only apparent remedy for this state of affairs, and the most promising means of putting the apple trade on a proper business basis, is for the growers in each apple growing section to unite to form a strong co-operative association through which the grading, packing, and marketing may be accomplished.

An effective co-operative association for this purpose, involves the selection of an honest, wide-a-wake, business manager, and the erection of a central packing and storage house at the most convenient point for shipment. Through such an organization boxes and barrels could be purchased wholesale to much better advantage; the grower could devote his whole attention to gathering the crop at the proper season and delivering it in good condition at the central packing house; the association would relieve him of all care and responsibility in grading, packing, and marketing; and with this work in the hands of expert packers, the grade would be uniform and the packing properly done, which would in time inspire confidence in the purchasing public. A good business manager could keep in close touch with the best markets and make sales when and where the fruit was most in demand. In short, consumers would be assured of a better product and growers would realize a better profit.

## Shipping.

Fom the time the fruit is picked, until it is placed on the market it should not be exposed to sun, rain, or frost, nor should it be subjected to rough or careless handling, which it too often receives when given over to the tender mercies of the transportation companies; and this is another particular in which a strong co-operative association would be more likely to affect improvement than individual shippers.

During the late autumn or winter months when the late keeping varieties are shipped, well ventilated cars or compartments on ship board afford the best meass of transportation if precaution be taken against freezing. During the warm weather of the summer and early autumn when the early maturing varieties are sent to market, shipment in cold storage is advisable. Cold storage retards maturity and delays decay, but does not prevent it. Transportation in cold storage gives the best results when the fruit has been thoroughly cooled before being placed in the car or steamer for shipment. Herein, too, the cold storage at the central packing house provides this for every shipment which could not always be obtained by the independent shipper.

## Storing.

The best keeping varieties of apples, when stored under proper conditions, may be kept the year round. The conditions necessary to the successful storage of apples are : a steady temperature, as near freezing as possible, without reaching that point; and an atmosphere moist enough to prevent wilting.

An ordinary house cellar usually furnishes the best place for the storage of the supply for domestic purposes. In such storage careful attention must be given to ventilation, as it is by this means principally that the temperature is regulated.

Before the fruit is stored it should be carefully picked over and all over-ripe, wormy, and bruised specimens should be culled from those intended for long keeping.

As there is always more or less risk in the storage of fruit, it is well for the grower who has apples to sell to hold the crop only so long as may be necessary to secure the best prices. For temporary storage in the fall a barn or other outbuilding may answer the purpose until severe freezing weather sets in. This is usually all the storing done by those who have but a small crop.

Where apples are grown or handled on a large scale, it pays to have a properly built fruit house, where the temperature and humidity inside can be controlled, and in which the crop may be held all winter if necessary. The walls of such a building are usually made of double thickness of matched lumber, with felt paper between and an air space between the studs. In such a house the crop may be packed and held for shipment as may be desirable any time during the fall or winter.

With the establishment of co-operative associations and central packing houses, the plan of the future will no doubt be central cold storage houses in connection with the packing houses, or at the points of shipment. In such houses the crop may be held under the most favorable conditions and put on the market whenever the demand warrants good prices.

## Apple Orchard Calendar.

January : Read best available literature on fruit growing. Attend Farmers' Institutes and work up co-operative organization. Make plans for new orchards.
Order nursery stock.

February : Order or make up supply of boxes and barrels for next season's crop.

March : Prepare for spring work by getting in readiness plows, cultivators, spraying outfits and materials, pruning tools, etc.
Get pruning done at earliest opportunity.

April : Plant out young orchards as soon as ground is ready.
Do your grafting.
Apply first spray of Bordeaux and Paris Green before buds start.
Plow under cover crop as soon as ground is dry. Apply wood ashes or other fertilizers necessary.

May : Complete any of the above operations not finished last month.
Repeat spraying before blossoms open.
Follow plowing by surface cultivation.

June : Spray immediately after blossoms fall.
Apply carbolic wash to trunks of young trees to prevent borers laying eggs. Continue surface cultivation to conserve soil moisture.

July : Repeat spraying for the fourth or fifth time, as may be necessary.
Discontinue cultivation towards end of the month and sow cover crop as last cultivation.
Thin fruit on young trees which may be overloaded.

August : Pick early apples intended for the market as soon as fully matured and well colored.
Let hogs in the orchard occasionally to pick up early windfalls.

September : Begin harvesting autumn varieties as they mature.
Get in touch with the leading apple markets if you have no co-operative organization to depend upon.
Make an exhibit at your fall show, and study varieties there exhibited.

October : Continue harvesting of the winter varieties, taking them in the order of their maturity.

November : Watch market reports closely and ship promptly if quotations warrant good prices.
Pack and store apples for further shipment or winter use.
Protect trunks of young trees against mice, rabbits, or sunscald as may be necessary upon approach of winter.

December : Continue apple shipments as may be necessary or advisable.
Attend annual meetings of Fruitgrowers' Association and Provincial Fruit Show, and keep in touch with progressive fruit growers.
Balance accounts for the year and decide upon lines of improvement for the next.

# INSECTS INJURIOUS TO THE APPLE.

By Wm. Lochhead, B.A., M.S.

## 1. Affecting the Roots.

The Woolly Aphis of the Apple (*Schizoneura lanigera*.) This insect is a small plant-louse with its body covered with a delicate, filmy cottony-like coat, which projects like a brush behind the body. It exists in two distinct forms, one inhabiting the roots and the other inhabiting the stems, the former being by far the more injurious. Throughout the summer the infested branches are very noticeable.

Galls and other enlargements arise on the affected roots, with the result that sooner or later death occurs. In the cracks which open up in the galls, the aphids live in clusters, and in a short time the vitality of the tree is very much reduced.

*Treatment.* Hot water, but little below the boiling point, when applied about the base of young trees in sufficient quantity to wet the soil to a depth of several inches, has been found to be effective and practicable. Tobacco stems, broken up finely and distributed about the base of the infested trees. The surface soil should be first removed, the tobacco applied, and the soil replaced. The roots of nursery stock suspected of bearing aphids should be dipped in a strong solution of tobacco stems, or in hot water (temp. 150 degrees F.) for a few seconds, or in hot soap solution, before the trees are planted.

## III. Affecting the Trunk, Twigs or Branches.

1. The Round-Headed Borer (*Saperda candida*). This borer is the grub of a brown beetle with two white stripes. It makes a round, oval tunnel in the trunk between the bark and the sapwood. At the end of the third year it changes to a pupa, which later changes into a winged beetle when it emerges. The eggs are laid on the bark in June and early July. The presence of this borer is betrayed by the sawdust-like castings at the opening of the tunnel, and by discolored bark.

*Treatment.* Probe or cut out the borer in fall and spring; apply to the trunk a white wash or carbolic soap wash before the first of June.

2. The Flat-Headed Borer (*Chrysobothris femorata*). This borer has a large, flat thorax, and makes a wide oval tunnel. It is probable that the borer becomes mature in one year. The adult is a bronzy, greenish black beetle, about half an inch long.

*Treatments*. Same as for Round-Headed Borer.

3. The Buffalo Tree-Hopper (*Ceresa bubalus*). A greenish insect, somewhat triangular in form, with an enormously developed prothorax, which projects in front into two horns. This insect does much harm by making slits in the bark, which open and form large oval scars.

The twigs and branches readily break at injured parts. The eggs are laid in the slits in July and August, and hatch the following June.

*Treatment.* Prune out affected branches and twigs in fall and spring.

4. Oyster-Shell Scale (*Mytilaspis pomorum*). This brown scale insect infests the bark. It has a shape like a minute oyster shell. It passes the winter as an egg under the old scale. The egg hatches about the first of June, and there is but one brood each year.

*Treatment.* Spray trees with white wash, lime-sulphur wash, or whale oil soap solution in winter; spray with kerosene emulsion solution when the eggs hatch and the young are crawling.

5. San Jose Scale (*Aspidiotus perniciosus*). This insect is quite minute, is circular with a central nipple. It winters as a half grown scale and matures about end of June. There are three or four broods each season. It injures the tree by sucking the sap. If the presence of this insect is suspected, a report should be made to the Department of Agriculture, Toronto.

*Treatment.* Spray in spring before buds open with lime-sulphur wash.

### III. Attacking the Buds and Leaves.

1. The Bud Moth (*Tmetocera ocellana*). The Bud Moth is a small, grayish insect which lays her eggs in July on the leaves. The young caterpillars feed on the under surface of the leaves. They pass the winter in a half grown state in small scales near the buds or other protected places. In spring they attack the swelling buds, often riddling them, and later form silken nests about the young leaves. The caterpillar is almost naked, brown with black head, and about $\frac{3}{4}$ of an inch long when full grown.

*Treatment.* Spray thoroughly with arsenic solutions just as the buds open.

2. Fall Canker-Worm (*Anisopteryx pometaria* and the Spring Canker-Worm (*Paleacrita vernata*). The females of these moths are wingless, the former depositing her eggs on the twigs in the fall, the latter in the spring. The caterpillars of both species are loopers, which attain a length of an inch. They feed on the leaves. When full grown they descend to the ground and change to pupæ in earthen cells. The moth of the Fall Canker-Worm appears in the fall, while that of the Spring Canker-Worm appears in the spring.

*Treatments.* Band the trunks of the trees in early fall with burlap or cotton to prevent the wingless females from ascending to lay their eggs. Spray with arsenic solutions, usually just before or after blossoming, when the caterpillars are small.

3. The Tent Caterpillar (*Clisiocampa Americana*). The web tents of these insects are often conspicuous in May, as the leaves appear. The caterpillar is hairy, and has a white-stripe down the back. The oval co-

coons are formed in protected places, and the yellowish-brown moths appear a week or so later to deposit bracelets of varnished eggs on the twigs. There is but one brood each season.

*Treatment.* Collect egg clusters in fall and winter; spray the young caterpillars with arsenic solution; burn or otherwise destroy the tents.

4. THE CIGAR CASE-BEARER (*Coleophora fletcherella*). Small cigar-shaped bodies may often be seen attached to the bark and leaves. These are the cases of tiny caterpillars which feed on the buds and leaves. In spring these caterpillars often do much harm. In late June or July the small moths appear to lay their eggs. When first hatched the caterpillars are leaf-miners, but later become case-bearers. They pass the winter in their cases, as half grown caterpillars.

*Treatment.* Spray thoroughly with arsenic solutions just as buds are opening and repeat if necessary a week later.

5. THE PISTOL CASE-BEARER (*Coleophora malivorella*). This Case-bearer is readily recognized by the pistol-shaped case which is attached to the branches. The small dark-colored moths appear at the end of June and deposit egg. The caterpillars hatch from the eggs in July, and eat holes in the leaves. They make cases for themselves as they feed. They spend the winter in the cases attached to the twigs. In early spring they recommence feeding on the opening buds and flowers. About the first of June they change to pupae, and the moths emerge two or three weeks later.

*Treatment.* Spray with arsenic solution as the buds are opening, and again a week later.

6. THE APPLE PLANT-LICE (*Aphis pomi et al*). These green plant-lice curl the leaves badly, and injure the buds. They are sucking insects and they secrete a sweet sticky liquid called honey-dew. They winter over as black, shining eggs on the branches of twigs. It is likely that there are more than one species. There are both winged and wingless forms during the summer.

*Treatment.* Spray when young plant-lice first appear with kerosene emulsion solution or any other good contact insecticide; spray with sulphur salt wash in early spring.

Several other insects are occasionally found injuring the leaves, viz., the APPLE-LEAF MINER, which mines within the leaf, and forms its pupa within the folded leaf; the APPLE-LEAF BUCCULATRIX, which forms white ribbed cocoons in clusters on the branches, while the caterpillars feed on the leaves; the PALMER WORM, a small yellowish green caterpillar, often numerous in June and July, when it injures the fruit as well as the leaves; the APPLE-LEAF TYER, which folds the leaf and lives within, feeding on the soft tissues; the APPLE-LEAF ROLLER, which feeds within folded leaves; the RED-HUMPED CATERPILLAR and the YELLOW-NECKED CATERPILLAR, which cluster on limbs and eat the leaves.

*Treatment.* As a rule spraying with arsenic solution at intervals during the season will control these.

## IV. Attacking the Fruit.

1. The Codling Worm (*Carpocapsa pomonella*). In the Eastern and Northern parts of Ontario there is but one brood, but in the South-western part there are two broods.

The small moths appear at the close of the blossoming period and deposit their eggs on the young fruit at the calyx end. The caterpillars bore into the fruit at the core, and when full grown, emerge and spin cocoons under the loose bark on the trunk in June and July, where they change into pupæ. Where there are two broods the moths appear in July and August to deposit eggs for a second generation. This brood of caterpillars may enter the half-grown apples at any point, but they emerge in the fall to form cocoons in which they remain hidden all winter. In spring they transform to pupæ, and later to moths just as the blossoms have fallen.

When there is but one brood the caterpillar after forming the cocoon remains in it until the following spring. The worms which fall to the ground with the apple make their way to some cover and form cocoons.

*Treatments.* Band the trunk with burlap or other suitable material about the tenth of June. Examine these bands every ten days or two weeks and destroy the cocoons which collect underneath; destroy the wormy and fallen apples; spray with arsenic solution soon after the blossoms have fallen; spray again in August to kill the young caterpillars of second brood.

2. The Apple Maggot (*Trypeta pomonella*). The adult of this Apple Maggot is a fly which deposits its eggs in the apple, and the maggots tunnel the fruit in every direction. They pupate in the ground or under any convenient cover.

*Treatment.* Prompt destruction of wind-falls. Spraying is not effective.

3. The Plum Curculio (*Conotrachelus nenuphar.*) This curculio does more harm in Ontario than the Apple Curculio. The fruit is often badly punctured and disfigured.

*Treatment.* Arsenical sprays will do much to control this insect, but so long as plum trees are uncared for, there will be much injury to apples.

4. Green Fruit Worms (*Xylina spp.*) There are several species of Green Fruit Worms. "There is but one brood in a year. They work mostly in May, pupate in the soil in June, live as pupæ during the summer and sometimes all winter, and most of the moths emerge in the fall and hibernate, laying their eggs in the spring." (Slingerland).

*Treatment.* Spray with arsenic solution before the blossoms open; cultivate ground in summer to kill the pupæ.

## FUNGUS DISEASES OF THE APPLE.

### I. Attacking the Fruit and Leaves.

1. The Apple Scab (*Fusicladium dendriticum, Venturia pomi*). This fungus first appears on the leaves in smoky greenish patches, upon which sooty pear-shaped summer spores are produced. Later it appears on the fruit, where it develops under the cuticle or outer layer of the skin, and forms dark brown, or blackish spots. It appears to thrive best in cool, moist weather, and on closely crowded trees. The scab passes the winter on infected fallen leaves, as black bodies imbedded in the leaf tissues.

*Treatment.* Plow under the dead leaves; spray with copper sulphate before the buds open, with Bordeaux soon after the leaves unfold and every two weeks thereafter until the danger is over; and prune so as to prevent overcrowding and shading.

2. The Ripe or Bitter Rot (*Glœosporium fructigenum, Glomerella rufomaculans*). This disease is very prevalent in Illinois and other Central States. Brown spots appear on the half-grown apple, these gradually enlarge and run together forming irregular patches. Black points often arranged in concentric circles form on the diseased areas. Spores ooze from the black points, and are carried to other apples by wind and rain. The fungus winters over in another form in diseased apples, but a stage of the fungus winters over on cankered limbs, which are the main sources of infection.

*Treatments.* Thorough spraying with Bordeaux; the destruction of old diseased fruit; the removal and burning of cankered limbs.

3. The Black Rot (*Sphæropsis malorum*). This fungus produces a characteristic disease. The early mature apples when affected first, become brown, with black discolored spots under the skin, later become black, and finally shrivelled, shrunken and wrinkled. The spores are formed in the small pustules readily seen in the dried up fruit and in the leaves. Paddock of Geneva has shown that this same fungus often produces cankers on the branches, which have open wounds made by sunscald, etc.

*Treatment.* Spray with Bordeaux four or five times during the season at regular intervals, burn or plow under the diseased fruit and leaves, scrape and coat with tar or paint the cankers on the larger limbs and cut off and burn those on the smaller.

4. Sooty or Fly-Speck Fungus (*Leptothyrium pomi*). This fungus injures mature apples under moist conditions, either in low moist ground or during a wet season. The popular names applied to this disease indicate quite accurately the character of the spotting of the fruit. Such varieties as Spy, Baldwin, and Greening are most susceptible to attack.

*Treatment.* Spray at regular intervals with Bordeaux, and select a high sunny position for orchard.

5. Fruit Spot (*Phyllachora pomigena*). This Fruit Spot has been quite common on Baldwins. It is recognized by sunken brown areas, which do not, however, sink very far into the flesh of the apple. The diseased spot has a bitter taste.

*Treatment.* Spray with Bordeaux.

The Powdery Mildew (*Podosphæra oxyacanthae*). This fungus sometimes injures apple leaves. White patches appear on both surfaces of the young leaves, run together, and form a white felt. There are both summer spores and winter spores, but the disease is not hard to contról, as it lives almost entirely on the surface of its host.

*Treatment.* Spray with Bordeaux at regular intervals.

The Apple Rust (*Gymnosporangium macropus*). This rust is peculiar in that it requires the red-cedar, as a second host, to complete its development. The so-called "cedar-apples" contain spores which may infect the leaves of apples and cause orange-yellow spots on the upper surface and scurfy bunches on the lower. The spores from the apple leaves in turn infect the red-cedar.

*Treatment.* Remove red-cedars if practicable and feasible.

## II. Attacking the Stem, Root, Trunk and Branches.

Apple Tree Cankers These cankers are irregular, sometimes concentric, open wounds on the trunk, branches, or twigs. The bark is first destroyed by bruises or by sun-scald, and injurious fungous spores affect an entrance. It has been proved that cankers may be produced by (1) the *Bitter Rot* fungus, (2) the *Black Rot* fungus, and (3) the *Nectria*. The Nectria is not common in Ontario but the first and second species of cankers are too common.

*Treatment.* Remove and burn cankers on smaller limbs and twigs, and scrape and coat with tar or paint those on the trunk and larger limbs; protect the trunks of trees subject to sun-scald; spray for Bitter Rot and Black Rot.

Crown Gall (*Dendrophagus globosus*). This slime fungus produces enlargements or galls on the roots near the surface of the ground. Such galls have been observed mainly on nursery stock in the United States. The disease has not yet become either dangerous or injurious in Ontario.

*Treatment.* Remove affected tree and burn.

1. Twig, Fire, or Pear-Blight (*Bacillus amylovorus*). This bacterial disease, so destructive to the pear, is also prevalent in apple orchards. The bacterium enters through the blossoms, and perhaps through wounds and insect punctures. As a rule, the terminal flowers, leaves, and twigs are first killed, the diseased parts appearing as if scorched by fire. The bark becomes black or brown, and the inner bark and cambium are destroyed. The disease travels backward into the branches, so that in time the entire tree may be killed. The injury is most marked in rapidly growing trees. It is believed that bees are the unconscious agents of infection

of the blossoms, as they have been seen to feed on the drops of a gummy containing multitudes of bacteria, which ooze from ruptures in affected twigs, and then to visit soon afterwards the blossoms.

*Treatment.* Cut off and burn affected twigs and branches whenever they appear. The limbs should be cut off 4 to 6 inches below the diseased part.

---

## Preparation of the Best Insecticides and Fungicides.

### *I. Bordeaux Mixture.*

| | |
|---|---|
| Copper sulphate (blue stone) ......... ............ | 4 pounds. |
| Fresh stone lime ......... ......... ......... ......... | 4 pounds. |
| Water ...... ...... ...... ...... ...... ...... ...... | 40 gallons. |

(1) Make a stock solution of bluestone by dissolving 25 pounds in warm water in a barrel and add water to make up to 25 gallons. Every gallon of this solution in first barrel contains one pound of blue stone.

(2) Into a second barrel put 25 pounds of fresh stone lime, and add with stirring small quantities of water to slake it. When fully slaked make up to 25 gallons by adding water. Every gallon of milk of lime in this second barrel contains one pound of lime.

To prepare the Bordeaux, empty 4 gallons of blue stone solution into the spray tank or barrel, which already should have 25 or 30 gallons of water in it; stir the milk of lime thoroughly and empty 4 gallons of it through the strainer into the spray barrel with constant stirring; then add water to make up to 40 gallons.

Any one of several arsenical compounds may be used along with the Bordeaux to form a combination insecticide and fungicide. The following are among the best:

(a) *Paris Green.* Add 4 to 6 ounces to 40 gallons of Bordeaux.

(b) *Arsenite of Soda.* Boil together for 15 minutes one pound white arsenic, 4 pounds sal soda, and 2 gallons water, until a clear solution is obtained. Add 1 to 1½ quarts to 40 gallons of Bordeaux.

(c) *Arsenite of Lime.* Boil together for 45 minutes 1 pound arsenic, 2 pounds fresh lime, and 1 gallon of water. Add one quart of this solution to 40 gallons of Bordeaux.

### *II. The Lime-Sulphur Wash.*

| | |
|---|---|
| Fresh Stone Lime ...... ...... ...... ...... ... | 20 pounds. |
| Sulphur (flowers) ... ...... ...... ...... ...... | 15 pounds. |
| Water ......... ......... ......... ...... ......... | 40 gallons. |

With warm water make the sulphur into a paste; put in the lime and add about 15 gallons warm water with stirring. The Sulphur made into a paste may be added after the lime has been slaked. Boil for an hour and a half in a kettle or in a barrel with live steam. Make up to 40 gallons; strain into spray tank and apply while warm.

Other lime-sulphur washes, made without the addition of external heat, are being tested, but their effectiveness has not been definitely ascertained.

*III. Kerosene Emulsion* (For Bark-Lice and Plant Lice).

| | |
|---|---|
| Hard soap ...... ......... | ½ pound, or soft soap 1 quart. |
| Boiling water (soft) ... ...... ...... ...... ...... | 1 gallon. |
| Coal oil ...... ...... ...... ...... ...... ...... ... | 2 gallons. |

After dissolving the soap in the water, add the coal oil and stir well for 5 to 10 minutes. When properly mixed, it will adhere to glass without oiliness. A syringe or pump will aid much in this work. In using, dilute with from 9 to 15 parts of water. Kerosene emulsion may be prepared with sour milk (1 gallon), and coal oil (2 gallons), no soap being required. This will not keep long.

*IV. Tobacco Decoction.*

| | |
|---|---|
| Refuse tobacco ... ... ...... ...... ...... ...... | 2 pounds. |
| Water ......... ......... ...... ......... ......... | 5 gallons. |

Boil the mixture for 30 minutes or more, until a dark brown tea-colored solution is obtained. Keep it covered until cool. It may then be used undiluted for spraying infested plants.

*V. Whale Oil Soap.*

For Plant Lice.—1 pound in 7 gallons hot water.

For San Jose Scale in Winter.—2 pounds in 1 gallon hot water applied as the buds are swelling.

*VI. Crude Petroleum.*

Undiluted crude petroleum may be used in late winter on apple trees for the San Jose Scale, but the trees should be dry, and no part should be sprayed more than once.

*VII. Wash for Borers.*

First, add soft soap to a saturated solution of washing soda to make a thick paint, then add 1 pint crude carbolic acid, and ½ pound Paris Green to 10 gallons of wash.

To be applied to the trunks of apple trees in early June.

### *VIII. Lime Wash.*

Slake $1\frac{1}{2}$ pounds fresh lime in 1 gallon of water. Strain the wash before spraying. To be applied during winter to trees infested with Oyster-Shell Bark lice.

### *Orchard Spraying.*

Spraying is now generally practised by our best apple growers and the most successful growers are the firmest believers in the value of, and necessity for, *thorough, intelligent spraying.*

Thorough, intelligent spraying means (1) the use of a good spray-pump and outfit, (2) a knowledge of the enemies to be treated, (3) a knowledge of the remedies which have been found most effective, and their preparation, and (4) the proper time for the application of the remedies. It should be remembered that prevention of fungous diseases is possible, but their cure is hardly practicable.

The following spray Calendar for an apple orchard will be found very helpful to the grower who makes an honest effort to spray successfully.

A Spray Calendar for an Apple Orchard.

| Application. | When to Spray. | Insects and Fungi Controlled. |
|---|---|---|
| Lime-wash | In winter | Oyster-shell scale, scurfy scale. |
| Lime-sulphur wash or Crude Petroleum | In early spring while trees are still dormant | San Jose scale, oyster-shell scale, and aphids. |
| 1. Bordeaux, and Paris Green or other arsenical compound | Just as leaf-buds are expanding | Bud moth, case-bearers, scab, bitter-rot, black rot. |
| 2. Bordeaux, and Paris Green or other arsenical compound | Just before blossoms open | Canker-worms, tent-caterpillars, bud-moth, case-bearers, etc., scab, bitter-rot, black rot. |
| 3. Bordeaux, and Paris Green or other arsenical compound | Just after blossoms fall | Codling moth, cankerworms, tent-caterpillars, etc., scab, bitter-rot, etc. |
| 4. Bordeaux, and Paris Green or other arsenical compound | Ten days or two weeks later | Codling moth, palmer worm, apple bucculatrix, curculio, scab, bitter-rot, etc. |
| 5. Bordeaux, and Paris Green or other arsenical compound | Two weeks later—in July | Scab, bitter-rot, etc. |
| 6. Bordeaux, and Paris Green or other arsenical compound | When second brood of Codling moths appears in August | Codling moth, scab, bitter rot. |

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BULLETIN 145

# Butter Preservatives

By

H. H. DEAN, Professor of Dairy Husbandry

and

R. HARCOURT, Professor of Chemistry

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Ontario Agricultural College and Experimental Farm.

# BUTTER PRESERVATIVES.

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Butter is composed of fat, water, curd, and a small amount of mineral matter. Fat is the most important constituent, and forms 84 to 87 per cent. of the butter. Butter fat is an extremely complex substance, composed of fatty acids in combination with glycerine. It differs from other fats, such as lard, tallow, etc., in that it contains a larger number of these glycerides. Besides the glycerides of the insoluble and non-volatile acids found in all fats, butter contains notable quantities of the glycerides of soluble and volatile acids. Some of these acids have a decidedly disagreeable odor, and, if by any means the glycerides containing these acids are decomposed, very strong rancid odors are developed. Furthermore, some of the fats are unsaturated compounds, which more or less rapidly combine with the oxygen of the atmosphere and thus set in motion changes which may not only destroy the pleasant aroma of good butter, but may also produce the disagreeable rancid smell common to bad butter.

The amount of curd in butter is not large, and, while it readily undergoes purtrifactive changes, does not appear to directly affect the keeping quality of the butter.* It serves, however, as food for the micro-organisms which cause the change and thus tends indirectly to produce bad flavors.

It is thus evident that the constituents of butter in their natural state are all delicate substances, some of which, or a combination of the whole, produce the peculiar aroma of good butter, and that the bad flavors are produced partly, at least, through the decomposition and oxidation of these substances. Most of these changes are doubtless due to the action of ferments which also produce compounds of an unpleasant nature. In addition to this, butter may have undesirable taints due to improper feeding of the cows, lack of care in treatment of the milk and cream, and to carelessness in the manufacture of the butter. Many of the faults of butter, due to these various causes, can be overcome. It is only by exercising the utmost care in every detail, from the production of the milk to the manufactured butter, that an article of the desired quality can be secured. But all butter, no matter how carefully it is made, will go "off flavor" in a comparatively short time.

*College Report, 1902, page 39.

The most common substance added to butter as a preservative is salt. The use of salt, together with the practice of storing butter in such a manner as to exclude air and light to prevent oxidation of the unsaturated fats, and at a low temperature to retard the action of ferments, has been, on the whole, fairly successful in retaining the good qualities of butter. In our export trade, however, new conditions are arising, and the dairyman has now to cater to a market which demands practically a saltless butter. To meet these new conditions he is compelled to cease using the only preservative with which he is familiar. Further, many creameries are not provided with cold storage plants, and are thus not able to use even this method of lengthening the commercial life of butter. Under these conditions it is not strange that butter-makers have commenced to use some of the brands of preservatives which are now so extensively advertised, especially when their use is advised by the wholesale dealers to whom they sell.

## Chemical Preservatives.

It is only in comparatively recent times that the real nature of fermentation, decay, and all such cases has been clearly understood. From time immemorial foods have been preserved by drying, smoking, placing in strong brine, in alcohol, or in vinegar, but it was not until after the work of Pasteur and others had shown that fermentation and decay are primarily caused by minute organisms, and that these organisms could not grow without moisture, in salt solutions, alcohol, or vinegar, that the true nature of these methods of preserving foods was understood.

Concurrently with the development of the science of bacteriology the study of chemistry has made known many chemical compounds which will destroy or retard the growth of these organisms. Many of these, such as bichloride of mercury, sugar of lead, etc., while powerful preservatives, are very poisonous, and for obvious reasons could not be utilized as food preservatives. In order to be used for this purpose, a substance must be almost without taste or smell, it must not be so noxious as to cause any immediate or serious results to the health of the consumer, it must be comparatively cheap, and yet so strong in its action on the lower organisms that only a small amount need be added to the food which it is desired to preserve. It is evident that the presence of small quantities of such substances in food would not be noticed by the consumer. In this they differ from the old preservative agents, such as sugar, salt, etc., which are condimentary in character, and reveal themselves by taste to the consumer.

At the present time the chief chemical compounds, other than salt, sugar, and alcohol, used in the preservation of foods are as follows:

1. Boric or boracic acid and borates.
2. Formalin or formaldehyde.
3. Salicylic acid.

4. Sulphurous acid and sulphites.
5. Benzoic acid or benzoates.
6. Fluorides.

The boron preservatives are apparently the most commonly used, and are preparations of boric acid and borax, with or without admixture of other preservative ingredients, such as salt, saltpetre, sugar, sodium carbonate, etc. They are used largely in milk, cream, and butter for preserving meat food generally, and to a smaller extent in beverages.

Formalin is a 40 per cent. solution of formaldehyde. As a preservative it is used chiefly in milk. In concentrated solutions it has a strong irritant odor, but when added to milk in quantities sufficient to retard fermentative action, it cannot be detected by taste or smell. The addition of formalin to milk is undoubtedly objectionable, as it interferes with digestion.

Salicylic, sulphurous, and benzoic acids and the fluorides are apparently used to some extent in dairy products, but more commonly in meat, fruit, vegetable preparations, beverages, etc. Salicylic acid is a powerful preservative, but it has a sufficiently characteristic taste to prevent it being used except in very minute quantities as a butter preservative.

Nearly all the preservatives now on the market are advertised as being "entirely wholesome," or that "its ingredients are all as healthful as salt," "capable of keeping the various articles of food perfectly sweet and fresh for any length of time, without the use of ice," etc. They are sold under a great number of fancy names, which, as a rule, give no clue to their real nature. On account of the perishable nature of foods, it is obvious that a substance having the properties claimed for the various commercial food preservatives would be of incalculable value. At the same time, we must recognize the fact that authorities differ as to the correctness of these claims, even for the boron compounds, which are possibly the least harmful of all the newer preservatives. While it would be very convenient to preserve foods by their use, it is important that nothing be added to foods which is toxic in itself, or which interferes even to the slightest extent with the process of digestion. This last point is especially important in dealing with the food of children and invalids.

The preservatives now in use may be divided into two classes: those which are undoubtedly injurious, such as formalin, the fluorides, salicylic and sulphurous acids, and those whose toxic action is disputed. The boron compounds belong to this latter class, and because of their extensive use in preserving dairy products, are of especial importance to dairymen.

Numerous methods have been made to ascertain whether the use of boric acid or borax in small quantities was or was not injurious, but no definite conclusions have been reached. Many distinguished English, German and French scientists have performed elaborate experiments with dogs, rabbits, guinea pigs, and human beings, and have come to opposite conclusions. The most elaborate experiment of this nature was recently conducted by Dr. H. W. Wiley, Chief Chemist of the Bureau of Chemistry, Department of Agriculture, Washington,* in which twelve young men, under close supervision, were given definite amounts of boracic acid and borax with their regular food. Dr. Wiley thus sums up the results of the effect of these preservatives upon the general health of the young men :

"The most interesting of the observations which were made during the progress of the experiments was in the study of the direct effect of boric acid and borax, when administered in food, upon the health and digestion. When boric acid, or its equivalent in borax, is taken into the food in small quantities, not exceeding half a gram (7 1-2 grains) a day, no notable effects are immediately produced. The medical symptoms of the cases in long-continued exhibitions of small doses, or in large doses, extending over a shorter period, show in many instances a manifest tendency to diminish the appetite and to produce a feeling of fullness and uneasiness in the stomach, which in some cases results in nausea, with a very general tendency to produce a sense of fulness in the head, which is often manifested as a dull and persistent headache. In addition to the uneasiness produced in the region of the stomach, there appear in some instances sharp and well-located pains which, however, are not persistent. Although the depression in the weight of the body and some of the other symptoms produced persist in the after periods, there is a uniform tendency manifested after the withdrawal of the preservative toward the removal of the unpleasant sensations in the stomach and head above mentioned."

"The administration of boric acid to the amount of 4 to 5 grams per day, or borax equivalent thereto, continued for some time results in most cases in loss of appetite and inability to perform work of any kind. In many cases the person becomes ill and unfit for duty. Four grams per day may be regarded then as the limit of exhibition beyond which the normal man may not go. The administration of 3 grams per day produced the same symptoms in many cases, although it appeared that a majority of the men under observation were able to take 3 grams a day for somewhat protracted period and still perform their duties. They commonly felt injurious effects from the dose, however, and it is certain that the normal man could not long continue to receive 3 grams per day."

"In many cases the same results, though less marked, follow the administration of borax to the extent of 2 grams and even of 1 gram per day, although the illness following the administration of borax and boric acid in those proportions may be explained in some cases by other causes, chiefly grippe."

"The administration of borax and boric acid to the extent of one-half gram per day yielded results markedly different from those obtained with

*Bureau of Chemistry, Department of Agriculture, Washington, Bulletin No. 84.

larger quantities of the preservatives. This experiment, Series V., conducted as it was for a period of fifty days, was a rather severe test, and it appeared that in some instances a somewhat unfavorable result attended its use. On the whole the results show that one-half gram per day is too much for the normal man to receive regularly. On the other hand it is evident that the normal man can receive one-half gram per day of boric acid, or of borax expressed in terms of boric acid, for a limited period of time without much danger of impairment of health."

"It is, of course, not to be denied that both borax and boric acid are recognized as valuable remedies in medicine. There are certain diseases in which these remedies are regularly prescribed, both for internal and external use. The value which they possess in these cases does not seem to have any relation to their use in the healthy organism except when properly prescribed as prophylactics. The fact that any remedy is useful in disease does not appear to logically warrant its use at any other time."

"It appears, therefore, that both boric acid and borax, when continuously administered in small doses for a long period, or when given in large quantities for a short period, create disturbances of appetite, of digestion and of health."

In 1899 the British Government appointed a departmental committee of experts to investigate the whole question of the use of preservatives and coloring matters in food.* This committee examined many witnesses, and certain members performed a large number of experiments. The conclusions arrived at by the committee relating to the use of preservatives in dairy products are of sufficient interest to be quoted here in full:

"The medical evidence, speaking generally, comprises for the most part opinion arrived at after a general consideration of the issues involved, but such opinion was not always based directly upon fact. The physiological evidence consists of the citation of the results of more or less exact physiological experiments. But, unfortunately, in the majority of cases the conditions under which the experiments have been made have only partially imitated those conditions which obtain in the actual taking of preservatives by the human subject to all ages for indefinite periods of time."

"Further, even supposing that we were to assume that the physiological experiments which have been laid before us did imitate with sufficient exactness the actual conditions obtaining in the inquiry in point, they would certainly do so only in so far as relates to the use of one preservative during a given period of time. The facts, however, show that in ordinary life what actually occurs is the simultaneous ingestion of more than one preservative. A further condition almost impossible of imitation by the physiological investigator is the consumption of these preservatives by all classes of invalids and by suckling. The absolute effect of these substances upon sucklings is at present unknown, and it is also

*Report of the Departmental Committeq appointed to enquire into the use of Preservatives and Coloring Matters in the Preservation and Coloring of Food—1901.

practically impossible to infer with accuracy from facts at present ascertained what would be the effect of, for instance, formic aldehyde upon a patient suffering from uraemia."

"A factor still more subtle in its influence upon the question before us is idiosyncrasy. Certain individuals are extremely sensitive to certain drugs, and it appears that among these drugs must be reckoned at least one of the agents used as a preservative. Although legislation covering all possible idiosyncrasies would be too complicated to be practical; nevertheless, it must be pointed out that as matters are at present, an individual possessing idiosyncrasy with regard to the poisonous action of boracic acid would not be able to profit even by his own experience. For since the addition of this substance to foods is not declared he might be continually made ill by the repeated involuntary consumption of articles of food containing it."

"The actual material upon which to base trustworthy conclusions not existed heretofore, in that the declaration of preservatives, and also a regulation of and notification of the amount thereof present in any preserved food must be regarded as a necessary preliminary to any accurate observations or statistics upon the subject. Had declaration of preservatives been in force during recent years, we should probably now have been in possession of medical evidence more directly based upon fact than that which we have had laid before us."

"Nothwithstanding the fact that trustworthy data as to actual injury are but few, there is evidence pointing to the probability that such injury does at times accrue. We cannot overlook the danger to which the uncontrolled use of drugs in the food of the population may be likely to give rise."

"Compounds of boracic acid have not been proved to be more hurtful than saltpetre to the consumer, yet saltpetre has been used from time immemorial in curing bacon, etc. The modern use of borax and boracic acid has enabled producers to dispense with a large proportion of common salt formerly necessary, thereby rendering bacon far milder to the palate, and protecting it from taint and fly-blow."

"After very carefully weighing the evidence we have come to the conclusion that as regards the trade in fresh and cured meat, fish, butter, margarine, and other food substances in the consumption of which but small quantities of the antiseptic are taken into the system, there exists no sufficient reason for interfering to prevent the use of boron preservatives. Even butter, of which the imports from all countries except Denmark frequently contain boracic acid, is not consumed in such quantities by individuals as to convey more than a very moderate daily amount of the drug into the system. The evidence satisfies us that the amount of preservative corresponding to 0.5 per cent. of boracic acid is sufficient for the purpose of preserving butter."

"But the circumstances and considerations affecting the milk traffic are very different. Milk, a very perishable substance, peculiarly liable to bacterial contamination, forms a very large proportion of the daily food of the public. The nutrition of infants and young children depends greatly on the purity and abundance of the milk supply; and, seeing how frequently milk is prescribed for invalids and convalescents, it is of the utmost importance that it should not be the vehicle of any unsuspected agent. While it is possible that milk containing boracic acid in sufficient quantity to act as a preservative (say 30 grams to the gallon) might be consumed to the amount of four or five pints a day, without harmful results by most healthy children or adults, there is evidence pointing to an injurious effect of boracised milk upon the health of very young children."

"Moreover, there exists at present no guarantee against the addition of excessive amounts of preservative to milk. In 1896 the Medical Officer of Health of Birmingham estimated the amounts of boracic acid in a number of milk samples. Of these, one-half showed boracic acid in a proportion not exceeding 21 grains per gallon; in one-fourth the proportion varied between 21 and 42 grains per gallon; while in the remaining fourth it ranged from 42 up to 126 grains per gallon. Professor Blyth instanced a sample of milk, purchased in Marylebone, containing, boracic acid in the proportion of no less than 80 grains to the pint. This occurred in December 1899, and the witness assured us that from time to time he had found an equally high proportion in milk samples taken in summer."

"Clearly such random use of any drug in a food calls for regulation. At present milk may be subjected to several successive treatments with preservative before it reaches the consumer. The farmer or producer sometimes applies it, so does the wholesale purveyor, so does the retail dealer; lastly, the domestic use of preservatives is increasing, and has become very general, and hence the milk may receive a fourth dose befor it reaches the unsuspecting consumer."

"There is this further objection to the use of preservatives in the milk traffic, that they may be relied on to protect those engaged therein against the immediate results of neglect of scrupulous cleanliness. Under the influence of these preservatives milk may be exposed without sensible injury to conditions which otherwise would render it unsalable. It may remain sweet to taste and smell and yet have incorporated disease-germs of various kinds, whereof the activity may be suspended for a time by the action of the preservative, but may be resumed before the milk is digested"

The following are the recommendations of the committee which were based upon the conclusions they arrived at from their experiments and from the evidence brought before them:

"(*a*) That the use of formaldehyde or formalin, or preservatives thereof, in foods and drinks be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 grain per pint in liquid food and 1 grain per pound in solid food. Its presence in all cases to be declared."

"(*b*) That the use of any preservative or coloring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Act."

"(*c*) That the only preservative which it shall be lawful to use in cream be boracic acid, or mixtures of boracic acid and borax, and in amount not exceeding 0.25 per cent., expressed as boracic acid. The amount of such preservative to be notified by a label upon the vessel."

"(*d*) That the only preservative to be used in butter and margarine be boracic acid or mixtures of boracic acid and borax, to be used in proportions not exceeding 0.5 per cent., expressed as boracic acid."

"(*e*) That in the case of all dietic preparations intended for the use of invalids or infants chemical preservatives of all kinds be prohibited."

"(*f*) That means be provided either by the establishment of a separate Court of Reference, or by the imposing of more direct obligation on the Local Government Board to exercise supervision over the use of preservatives and coloring matters in foods, and to prepare schedules of such as may be considered inimical to the public health."

It is evident that Dr. Wiley and the British Committee agree regarding the harmfulness of even the boron compounds when taken into the system in large doses. But, while Dr. Wiley contends that the continued use of small amounts for a long period will "create disturbances of appetite, of digestion and of health," the British Committee concludes that "there exists no sufficient reason for interfering to prevent the use of boron preservatives when used in fresh and cured meat, fish, butter, margarine, and other food substances in the consumption of which but small quantities of the antiseptic are taken into the system." Dr. Wiley's conclusions were reached after a comparatively long study of cases under direct medical supervision; the Committee's conclusions were reached from experiments of much shorter duration, and from the fact that although preservatives were found to be used quite extensively, very few cases of sickness had been traced to them.

To gather further information on this point and to ascertain what effects the small amount of preservative commonly placed in butter would have on the system, it was suggested that experiments be carried on with the students in residence at the College. A table of twelve men, from 18 to 22 years of age and in good health, eagerly volunteered for the work. All they were asked to do was to use the butter provided regularly and to report if they felt the least pain or any unusual sensation develop. The butter prepared for this experiment contained one-half of an ounce of salt per pound and one-half per cent. of borax. For twenty-six days during the fall term the twelve men used practically three pounds of butter per day and would, consequently, have consumed, provided all preservative was retained in the butter about .5 grams of borax per day. No ill effects were felt by any of the men. After the Christmas vacation the experiment was resumed, and, at the time of writing, has continued for fifty days, without any noticeable injurious effects. This experiment was not so accurately carried out as those of Dr. Wiley; it was intended only to test the effect of the preservative on the health of the men in a general way; but it tends to prove the conclusion arrived at by the British Commission.

On the other hand, while it is doubtless true that some, possibly the large majority of people may use boron preservatives without feeling any unpleasant effects, others may be seriously affected. Further, if preservatives of various kinds are used in a number of food substances and in beverages, it may happen that in the aggregate a large enough quantity be taken into the system to be harmful.

With the present available information regarding the effects of the so-called chemical preservatives on the human system, it is apparent that it would be unwise to recommend their use except in cases where the necessity is clearly manifest, and where it can be demonstrated that other methods of preservation are not applicable. Milk and cream certainly do not come under this list; for it has been abundantly demonstrated that with proper care these substances can be placed in the consumer's hands in good condition. Long experience has also proven that it not necessary to use preservatives in butter intended for home consumption. With export butter the case is somewhat different. It does not reach the consumer so quickly, and has to be shipped long distances, sometimes under very trying condition. Moreover, the trade demands a practically saltless butter, thus preventing the use of the preserving material used in the home trade. It is evident, however, that only boron preservatives should be used, and then in the smallest amount necessary to preserve the butter.

Another point that cannot be too strongly emphasized is that preservatives do not improve the butter; they simply preserve for a longer time the flavor developed in the fresh article. The flavor is influenced by many conditions in the production of the milk, care of the milk and cream, and in the manufacture of the butter, and is practically settled before the preservative is added. The preservative only helps to retain the particular flavor developed, and cannot be used to overcome slovenliness or carelessness in the manufacture of the butter.

During the last few years various brands of butter preservatives have been extensively advertised throughout the Province. Naturally, considerable interest is being taken in them, and many requests have come to us for exact information regarding their nature and use. To answer these questions more definitely, we decided to collect and examine a number of the commercial preservatives now on the market and to study their preserving or keeping properties when used in butter. The general plan of the work at the Dairy was as follows: The regular churning, which usually consists of 200 to 300 pounds of butter made from pasteurized cream, was divided into several lots,—one for each preservative tested. The small lot of fresh butter was taken from the large "Success" churn and placed in a small "Simplex" churn for working. After placing the butter in the churn the preservative was sifted over the butter, and distributed as evenly as possible. The worker attachment was then put in motion and the butter was given the usual amount of working—18 to 19 revolutions of the worker. In those experiments where salt was used with the preservative, the two were weighed separately and then thoroughly mixed before adding them to the butter. All the different preservatives were plainly labelled and after weighing were placed on papers marked with the name of the preservative. The boxes and prints were numbered at the time and a record made of the preservative together with the distinguishing number so that there could be no mistake and no mixing of the different lots. Every known precaution was taken that each lot should contain the preservative intended for it and no other. In all the summer experiments, one pound print wrapped in parchment paper, and one 28 lb. box were marked and placed in the refrigerator for scoring. The boxes were lined with heavy parchment paper which had been previously soaked for at least 24 hours in a brine and formalin solution. Every precaution was taken to prevent mould or unnecessary deterioration of the butter. Four lots were made from ripened cream and two from sweet cream. In all cases the cream had been previously pasteurized at a temperature of 180 to 185 degrees F.

## The Preservatives.

The commercial preservatives were secured from the different firms or their agents. We wrote all the Canadian firms whom we could hear of as selling goods of this class in Canada. We explained the nature of the work we intended doing and asked them to send us a sample of their regular goods. Most of the firms cheerfully donated sufficient for our work. The borax, boracic acid and sodium fluoride were purchased from chemists. The salt was a portion of that from our regular supply.

Each of these preserving substances was submitted to a close chemical examination, the results of which are given below. The number of the chemical preservatives will be used to designate these substances hereafter.

No. 1 Commercial borax containing chlorine equivalent to 1.64 per cent. of sodium chloride or common salt.

No. 2. Practically pure boracic acid.

No. 3. A commercial preservative containing 3.75 per cent. of common salt, balance boracic acid with a small amount of borax.

No. 4. A commercial preservative containing 5.41 per cent. of common salt, 9 per cent. saltpetre, balance borax and boracic acid.

No. 5. A commercial preservative containing 6.5 per cent. of common salt, balance borax and boracic acid.

No. 6. A commercial preservative containing 10 per cent carbonate of soda, balance borax and boracic acid.

No. 7. Common salt, practically free from impurities.

No. 8. A commercial preservative containing 27.48 per cent. of common salt, balance borax and boracic acid.

No. 9. Practically pure sodium fluoride.

No. 10. A commercial preservative containing 1.60 per cent. of salt, balance borax and boracic acid.

Preservatives 8 and 9 were used only in September experiments. No. 10 was used only in December. The quantity was either one-quarter of one per cent. or one-half of one per cent. In the two experiments of July 26 and 27, one-quarter of one per cent. each of borax and boracic acid was used, and one-half per cent. of the commercial preservatives. When salt and preservatives were mixed, one-quarter of one per cent. of each was used. When salt alone was added the rate was 3-4 of an ounce per pound of butter or about 4 1-2 per cent.

## The Treatment of the Butter.

Immediately after the butter was worked and packed or printed, it was taken to an ice cold-storage where the temperature was about 40 degrees F. The lots made July 14, 21, 26 and 27, were scored the first time on July 30th. The July lots were scored the second time on September 13th and again, together with the September lots, on October 4th. All the July boxes and the boxes made on September 13th were taken out of the refrigerator and sent to Montreal on October 17th. They were placed in cold-storage on arrival at Montreal and were scored November 2nd, 1904, by Messrs. A. W. Woodard, official referee, Vaillancourt, Olive, Ayer, and LeClair. The samples were known to these judges by numbers only. It was not possible for them to know what kind of preservative had been used in the several packages.

## The July Butter Scores.

As the flavor is of the most important quality in butter this was the chief point noted in the experiments. Unless something special was observed, no other point than flavor was judged. The Commercial Preservatives are indicated by number only. The same number will be given in all the scorings.

| Preservatives. | Flavor 45. Av. First Scores. | | Flavor 45 Av. Second Scores (45 days later). | |
|---|---|---|---|---|
| | Prints. | Boxes. | Prints. | Boxes. |
| 1. Borax | 41.6 | 41.5 | 41.7 | 37.7 |
| 2. Boracic Acid | 42.0 | 41.5 | 41.0 | 36.2 |
| 3. Commercial Preservative | 42.0 | 41.6 | 41.5 | 35.5 |
| 4. " " | 42.1 | 41.6 | 41.5 | 37.5 |
| 5. " " | 42.1 | 41.3 | 41.7 | 37.0 |
| 6. " " | 42.0 | 40.8 | 41.2 | 37.2 |
| 7. Common Salt | 42.2 | 41.2 | 37.5 | 35.2 |

It will be noticed that the lots of butter in pound prints seemed to have held their flavor for 45 days better than did the lots in boxes, although all were in the same refrigerator. The greatest depreciation was in the lots where common salt and No. 3 preservative were used, and the least in the cases of Nos. 1 or borax and 6.

## One-Half and One-Quarter of One Per Cent Compared.

The maximum quantity of preservative recommended by the manufacturers is usually one-half of one per cent. In order to compare one-half and one-quarter of one per cent. and also 1-4 per cent. mixed with salt as to effectiveness in preserving butter, these two quantities were used in some of the experiments. The following table gives the average of the Montreal scores which were made on November 2nd, about 3 1-2 months after the first lots were made and six weeks after the making of the freshest lot.

| Preservative. | Av. Scores for Flavor. Max. 45 | | |
|---|---|---|---|
| | $\frac{1}{2}$% | $\frac{1}{4}$% | $\frac{1}{4}$% pre. and $\frac{1}{4}$% salt. |
| 1. Borax | 40.2 | 40.5 | 36.7 |
| 2. Boracic Acid | 34.5 | 39.5 | 37.5 |
| 3. Commercial Preservative | 39.9 | 41.0 | 39.0 |
| 4. " " | 38.8 | 41.0 | 39.7 |
| 5. " " | 39.2 | 41.0 | 40.4 |
| 6. " " | 39.8 | 41.7 | 39.2 |

The scorings indicate that one quarter of one per cent. of preservative is as effective as one-half of one per cent. under the conditions named, in fact the averages for flavor were higher in the lots to which one-quarter of one per cent. was added due no doubt to the fact that the lesser amount does not impart the "preservative flavor" which most of the judges commented upon, as will be seen farther on. The addition of one-quarter of one per cent. of salt to the preservatives appeared to lower the average scores.

## Ripened vs. Sweet Cream Butter.

In order to compare the effects of the preservatives and salt on butter made from ripened and sweet cream the scores of the four lots made from ripened cream and of the two from sweet cream are given separately with the following average results in flavor for both prints and boxes.

| Preservative. | Flavor 45 Ripened Cream Butter | | | Flavor 45 Sweet Cream | | |
|---|---|---|---|---|---|---|
| | Dairy Scores | Montreal Scores | Average | Dairy Scores | Montreal Scores | Average |
| 1. Borax. . . . . . . . . . . . . . . | 40.7 | 39.7 | 40.2 | 41.0 | 39.5 | 40.2 |
| 2. Boracic Acid. . . . . . . . . | 40.4 | 37.8 | 39.1 | 40.6 | 39.0 | 39.8 |
| 3. Commercial P. . . . . . . . | 40.3 | 39.9 | 40.1 | 40.8 | 40.0 | 40.4 |
| 4. " " . . . . . . . . | 40.7 | 39.3 | 40.0 | 41.3 | 40.0 | 40.6 |
| 5. " " . . . . . . . . | 40.6 | 39.7 | 40.1 | 41.1 | 40.0 | 40.5 |
| 6. " " . . . . . . . . | 40.3 | 39.8 | 40.0 | 41.0 | 41.2 | 41.1 |
| 7. Salt . . . . . . . . . . . . . . . . | 38.6 | 33.8 | 36.2 | 40.7 | 40.0 | 40.3 |
| 8*. Commercial P. . . . . . . | 40.5 | 42.5 | 41.5 | 41.5 | † | 41.5 |
| 9*. Sodium Fluoride. . . . | 36.0 | 40.0 | 38.0 | 37.0 | † | 37.0 |

* Used only in Sept. expts. † Not sent to Montreal.

Two points are brought out in these scorings.

1. The average for flavor was higher in the lots made from sweet cream both in the Dairy and Montreal scores. This was specially so in the samples where common salt alone was used.

2. There was not much difference in the average scorings for the different preservatives other than for salt and sodium fluoride, although the latter was given a comparatively high score at Montreal. It will also be noticed that the borax lots have averaged about the same as did those in which commercial preservatives were used.

One-quarter per cent. borax and one-quarter per cent. boracic acid, one-half per cent. commercial preservatives, and three-quarters of an ounce of salt compared. One experiment only.

| Preservative and amount. | Flavor Max. 45 | Flavor Max. 45 | Flavor Max. 45 |
|---|---|---|---|
| | Average Daily Scores | Av. Montreal Scores | Average Of All |
| 1. Borax ¼% . . . . . . . . . . . . . . . . . . . . . . . . | 40.7 | 39.5 | 40.1 |
| 2. Boracic Acid ¼% . . . . . . . . . . . . . . . . . . . . | 40.2 | 39.0 | 39.6 |
| 3. Commercial P. ½% . . . . . . . . . . . . . . . . . . | 40.5 | 40.0 | 40.2 |
| 4. " " ½% . . . . . . . . . . . . . . . . . . | 41.2 | 40.0 | 40.6 |
| 5. " " ½% . . . . . . . . . . . . . . . . . . | 41.0 | 40.0 | 40.5 |
| 6. " " ½% . . . . . . . . . . . . . . . . . . | 41.0 | 41.2 | 41.1 |
| 7. Salt ¾ oz. . . . . . . . . . . . . . . . . . . . . . . . . | 40.7 | 40.0 | 40.3 |

In this experiment preservative No. 6 seems to have given the best results, although there is not so very much difference in the average scorings of all the lots including salt. With the sweet pasteurized cream the salt appears to have given nearly as good results as the preservatives.

Detailed Scoring of the Lots Sent to Montreal.

As previously explained, all the July lots and one of the September lots were sent to Montreal and were scored by the experts on November

2nd. The following table gives the details of the scores together with the judges comments on each lot.

REPORT OF SCORES ON BUTTER SENT TO MONTREAL AND SCORED, NOV. 2, 1904.

| No. of Sample. | Kind of: Cream. | Kind of: Preservative in Butter. | Date of Making. | Score for Flavor, Max 45. Individual Scores. (1) | (2) | (3) | (4) | (5) | Av. | Av. of all. | Remarks of Judges: |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ripe | 1. Borax ½% | July 14 | 40 | 41 | .... | 40 | 40 | 40.2 | | Irregular color, gritty, well kept, sweet, pre. flavor |
| 8 | " | Borax ¼% Salt ¼% | " 21 | 38 | 39 | .... | 35 | 35 | 36.7 | | Oily, irregular color, gritty. |
| 15 | " | Borax ¼% | " 26 | 40 | 40 | .... | 42 | 41 | 40.7 | 39.7 | No taste, no smell, little off. |
| 22 | Sweet | " ¼% | " 27 | 40 | 37 | 40 | 40 | 41 | 39.5 | | Mouldy. |
| 29 | Ripe | " ¼% | Sept. 13 | 41 | 42 | 39 | 45 | 40 | 41.1 | | Cloudy to mottled, beginning to mould. |
| 2 | Ripe | 2. Boracic A ½% | July 14 | 37 | 32 | .... | 30 | 39 | 31.5 | | Stale, fishy. gritty; pre. taste and smell. |
| 9 | " | Boracic A ¼% Salt ¼% | " 21 | 37 | 41 | .... | 35 | 37 | 37.5 | | Fishy, poor. |
| 16 | " | " " ¼% | " 26 | 40 | 40 | .... | 39 | 41 | 40 | 38.1 | Slightly fishy, mouldy, trifle stale. |
| 23 | Sweet | " " ¼% | " 27 | 39 | 41 | .... | 40 | 36 | 39 | | Mouldy, flavor not accountable for. |
| 30 | Ripe | " " ¼% | Sept. 13 | 37 | 42 | .... | 41 | 38 | 39.5 | | Beginning to mould, even color. |
| 3 | Ripe | 3 ½% | July 14 | 40 | 33 | .... | 40 | 42 | 38.7 | | Stale, sweet. |
| 10 | " | 3—¼% & ¼% Salt | " 21 | 39 | 39 | .... | 38 | 40 | 39 | | Very little fishy, very little taste pre. |
| 17 | " | 3 ½% | " 26 | 41 | 41 | .... | 42 | 41 | 41.2 | 39.9 | Mouldy. |
| 24 | Sweet | 3 ½% | " 27 | 40 | 40 | .... | 39 | 41 | 40 | | Very mouldy, gritty, very little foreign flavor. |
| 31 | Ripe | 3 ¼% | Sept. 13 | 41 | 43 | 36 | 42 | 43 | 41 | | Gathered cream, good. |
| 4 | Ripe | 4 ½% | July 14 | 35 | 41 | 30 | 37 | 40 | 36.6 | | Fishy, preservative smell. |
| 11 | " | 4—¼% & ¼% Salt | " 21 | 40 | 41 | .... | 38 | 40 | 39.7 | | Slightly stale, very little smell and taste. |
| 18 | " | 4 ½% | " 26 | 40 | 41 | .... | 37 | 42 | 40 | 39 4 | Slightly fishy, very mouldy. |
| 25 | Sweet | 4 ½% | " 27 | 39 | 40 | 42 | 40 | 39 | 40 | | Very mouldy, gritty. |
| 32 | Ripe | 4 ¼% | Sept. 13 | 40 | 43 | 38 | 44 | 40 | 41 | | Mottled color, beginning to mould, cooked taste. |
| 5 | Ripe | 5 ½% | July 14 | 38 | 41 | 32 | 40 | 42 | 38.6 | | Slightly stale, inclined to be fishy. |
| 12 | " | 5—¼% Salt ¼% | " 21 | 40 | 41 | 42 | 40 | 39 | 40.4 | | |
| 19 | " | 5 ½% | " 26 | 39 | 40 | .... | 39 | 38 | 39 | 39.8 | Slightly fishy, gritty, stale. |
| 26 | Sweet | 5 ½% | " 27 | 40 | 41 | .... | 41 | 38 | 40 | | Spotted, woody flavor, mouldy. |
| 33 | Ripe | 5 ¼% | Sept. 13 | 41 | 42 | 40 | .... | 41 | 41 | | Beginning to mould, a little gritty, preservative taste. |
| 6 | Ripe | 6 ½% | July 14 | 40 | 41 | 42 | 44 | 40 | 41.4 | | |
| 13 | " | 6—¼% Salt ¼% | " 21 | 39 | 40 | .... | 40 | 38 | 39.2 | | Peculiar flavor, special taste. |
| 20 | " | 6 ½% | " 26 | 38 | 40 | 32 | 38 | 37 | 37 | 40.1 | Fishy, mouldy, pre. taste. |
| 27 | Sweet | 6 ½% | " 27 | 41 | 41 | ... | 40 | 43 | 41.2 | | Gritty, woody, poor color, beginning to mould. |
| 34 | Ripe | 6 ¼% | Sept. 13 | 41 | 43 | 40 | .... | 43 | 41.7 | | Good, good. |
| 7 | Ripe | 7. Salt ¾ oz | July 14 | 35 | 27 | 29 | 32 | 37 | 32 | | Fishy, no mould, stale. |
| 14 | " | " ¾ oz | " 21 | 35 | 36 | 29 | 35 | 35 | 34 | | Fishy, no mould, stale. |
| 21 | " | " ¾ oz | " 26 | 35 | 33 | 32 | 37 | 34 | 35.6 | 35.4 | No mould. |
| 28 | Sweet | " ¾ oz | Sept. 27 | 38 | 41 | 39 | 40 | 42 | 40 | | No mould, well kept. |
| 35 | Ripe | 8 ¼% | Sept. 13 | 42 | 43 | .... | 42 | 43 | 42.5 | | |
| 36 | " | 8 Sodium Fl. ¼% | " 13 | 41 | 41 | 41 | 36 | 41 | 40 | | Too much preservative, gathered or old cream flavor, preservative taste. |

Judges: (1) Woodard, (2) Vaillancourt, (3) Olive, (4) Ayer, (5) LeClair.

The scorings of the Montreal experts bring out several points:

1. The variation in scores of the five judges is considerable, amounting in one case to as much as eleven points on the flavor.

2. The average scorings of all the July lots containing preservatives was quite uniform. The extreme variations were 38.1 to 40.1 out of 45. Boracic acid gave the lowest average score and preservative No. 6 slightly the highest.

3. The lots containing salt at the rate of 3-4 oz. per pound of butter averaged 35.4 out of a possible 45 for flavor. These lots were entirely free from mould, while all the other lots made in July were badly moulded.

## Experiment of September 14, 1904.

One of our regular churnings of sweet pasteurized cream on Sept. 14th, was divided into eight lots of 28 pounds in each box. To the butter in each was added one-quarter of one per cent. of preservative and the boxes were numbered as in the other experiments, and placed in cold-storage at about 40 degrees F.

The scorings on October 4th, 1904, and March 4th, 1905, were as follows:

| Preservative. | Score for Flavor. Max. 45. | | |
|---|---|---|---|
| | Oct. 4th, 1904. | Mar. 4th, 1905. | Average. |
| 1. Borax | 41 | 34 | 37.0 |
| 2. Boracic Acid | 42 | 32 | 37.0 |
| 3. Commercial Preservative | 42 | 33 | 37.5 |
| 4. " " | 42 | 36 | 39.0 |
| 5. " " | 42 | 35 | 38.5 |
| 6. " " | 42 | 34 | 38.0 |
| 8. " " | 42 | 35 | 38.5 |
| 9. Sodium Fluoride | 38 | 37 | 37.5 |

In this experiment, the lot made by using sodium fluoride as a preservative was given the lowest score on October 4th, 1904, and the highest score on March 4th, 1905. While sodium fluoride appears to be a very good preservative, owing to its apparent harmful effect on the human system it is not to be recommended. Another point brought out very markedly in this experiment was the fact that all the lots in which borax, boracic acid, and commercial preservatives were used had moulded vary badly in the storage, while the box in which sodium fluoride was used, contained no mould whatever.

## A Special Test.

On December 6th, 1904, nine pound prints and one 28 lb. box of butter were taken from one of our regular churnings. The objects of this experiment were:

1. To test the effects of one-half and one-quarter per cent. of preservatives and also salt on prints of butter kept in a warm room for about five weeks.

2. To compare the preservatives which we had been using in our previous summer work with a special, imported, commercial preservative which we shall designate as No. 10. We also wished to test this preservative with reference to mould.

The prints of butter wrapped in parchment paper were placed directly after making in a room where the temperature ranged from 60 to 70 degrees and remained there until January 13th, 1905, (38 days) when they were scored and afterwards moved to an ice cold-storage, where they remained at a temperature of 30 to 32 degrees F. until March 4th. They were again scored by five of the instructors in the Dairy School. The box was put in the ice storage as soon as made and was not scored until March 4th, 1905. At this date neither the box nor any of the prints had developed any mould. It is probable that the conditions of temperature and moisture in winter were unfavorable for its growth.

The scorings of the various lots as given by one of the writers on January 13th and by five instructors of the Dairy School on March 4th, were as follows:

| Preservatives. | Flavor 45. Score, Jan. 13th, 1905. | Flavor 45. Score, Mar. 4th, 1905. | Flavor 45. Score, Average. |
|---|---|---|---|
| 1. Borax ½% (print) | 35 | 36 | 35.5 |
| 1. " ¼% " | 30 | 25 | 27.5 |
| 4. Com. P. ½% " | 30 | 27 | 28.5 |
| 4. " ¼% " | 30 | 25 | 27.5 |
| 6. " ½% " | 35 | 35 | 35.0 |
| 6. " ¼% " | 37 | 30 | 33.5 |
| 7. Salt ¾ oz. " | 30 | 23 | 26.5 |
| 10. Com. P. ½% " | 32 | 35 | 33.5 |
| 10. " ¼% " | 30 | 27 | 28.5 |
| 10. " ½% (box) | ........ | 40 | ........ |

In this, what may be considered a severe test, the lots preserved with borax appear to have given as good or slightly better results than any of the commercial preparations. It would also seem that one-quarter of one-per cent of preservative did not hold the flavor of the butter so well as did the half per cent. and that salt was not nearly so good as the boron preparations. In this one trial the No. 10 commercial preservative did not give any better results than did those tested during the summer.

The box of butter put into cold-storage held its flavor much better than did the prints which were exposed to a high temperature for 38 days.

### Preservatives for Cream.

It has been recommended that patrons of cream-gathering creameries be supplied with a preservative to place in the cream to prevent its souring before delivery. A few trials were made of a special cream preservative, between July 16th and 25th. For these trials a large test tube was used having a cotton plug in the open end. The samples were kept at a temperature of 60 to 70 degrees F. in an ordinary room. The amount of preservative was as nearly as possible the proportion as recommended by the manufacturers. The following are some of the results:

July 18, 11.30 a.m. Pasteurized and cooled skim-milk placed in a added. Cream thick and sour 11 a.m., July 18th.

July 18, 11.30 a.m. Pasteurized and cooled skim-milk placed in a test tube and preservative added. Sample sour and thick 10 a.m. on the 20th.

July 20, 10 a.m. Skim-milk from separator which had not been pasteurized or cooled was added to test tube. Milk was separated at a temperature of 90 degrees F. Extra amount of preservative added. 9 a.m. on the 21st, sample sweet but had a bad flavor. On the 23rd at 3 p.m. sample slightly sour. Flavor not so bad as on the 21st. On July 25th, flavor improved and acid developed slightly more but not thick at 10.30 a.m. on the 25th. The sample was thick on the morning of the 26th.

While these trials are not conclusive, they point to the fact that a considerable amount of the preservative would have to be used to keep cream sweet in hot weather, and also indicate that though we may keep a sample sweet by this method, we do not prevent the development of bad flavors which may be more objectionable than simple souring.

### General Conclusions.

1. Powdered borax, in these experiments, has given as good results as the commercial preservatives, although manufacturers of the latter claim that borax is unsuitable as a preservative, as the following quotation from a letter received from one of the firms will show, "We know, from a number of experiments conducted under our personal supervision, provided well-made butter of a delicate flavor were in question the———treated butter must yield a finer flavor than borax-treater butter. Borax, as a matter of fact, is a most unsuitable preservative for butter as any practical butter manufacturer must know, as borax is alkaline in its action and would tend to saponify butter."

We do not find the foregoing results in our experiments, although further work is needed to settle the matter definitely. The borax costs about one-half as much per pound as the commercial preservatives.

2. One-quarter of one per cent. of powdered borax or of the commercial preservatives appears to be sufficient to hold the butter flavor under ordinary conditions, and is not nearly so liable to give the "preservative taste" to the butter. Butter which is likely to be held for over three months or which may be exposed to high temperatures may have one-half of one per cent. added.

3. The results indicated better keeping quality in the sweet cream butter than in those lots made from ripened cream.

4. There was not much difference in the keeping quality of the butters treated with the different preservatives, boracic acid giving the poorest average and commercial preservative No. 6 rather the nighest.

5. All the boxes and prints of butter made during the summer to which the borax, boracic acid, or commercial preservatives had been added developed mould very badly, while the samples which were salted were free from mould.

6. Under the severe test of December 6th, none of the preservatives may be considered as having given satisfactory results, although the flavor was very much better in those lots as compared with the lots treated with salt alone.

7. At the preent time we are not prepared to recommend the use of milk or cream preservatives.

8. For the home trade, with proper means for pasteurizing the cream and suitable cold-storage facilities, we do not consider that preservatives, other than salt, are needed to keep butter for a reasonable length of time.

9. For the export trade which allows one-half of one per cent. boracic acid in butter it would seem as if this amount might be used to advantage in some cases, but with suitable cold-storage and especially where pasteurization is followed, less than this amount would preserve the butter and be less liable to injure the consumer.

10. Salicylic acid, sodium fluoride, and formalin may not be recommended as butter preservatives. The first one is more or less harmful, and gives an objectionable flavor to butter, while the latter two are considered quite harmful to the human system.

# ONTARIO AGRICULTURAL COLLEGE BULLETINS.

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