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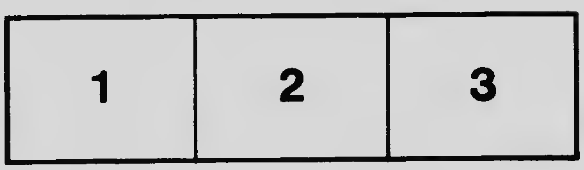
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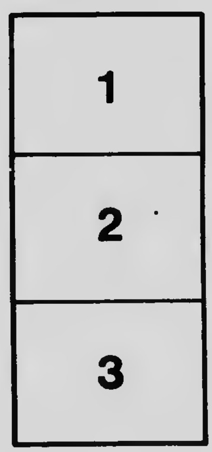
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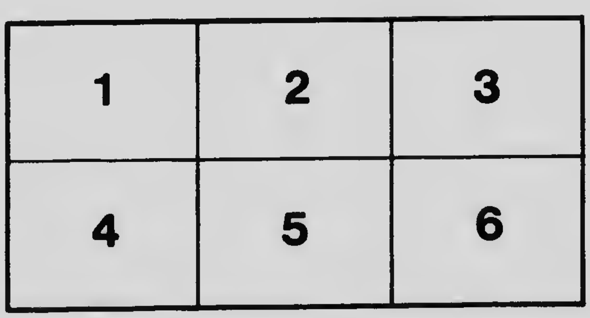
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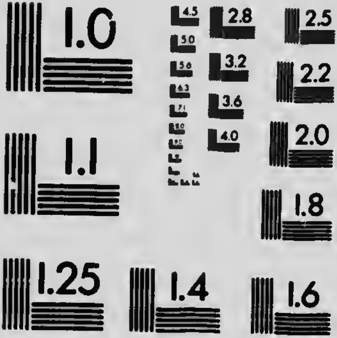


BULLETIN 265] [AUGUST, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

Bacteria—Friends and Foes

By D. H. JONES, B.S.A.

Nature of Bacteria.

Bacteria are microscopic plants. They are the smallest forms of life known, and in order to see them it is necessary to use the highest power microscope, together with other bacteriological apparatus. Some species of bacteria are so infinitely small that they can be only just discerned even with the highest magnifying microscopes, and it is considered that there are some which are even still smaller, being too small to come within our range of vision with all the aids known to science. The average size of the more common species of bacteria is about 1-10,000 of an inch in length and 1-20,000 of an inch in breadth.

In addition to being the smallest of living things, bacteria are the simplest of living things in their structure. They are unicellular, that is, their whole body consists of only one cell. The bacterial cell is composed of protoplasm enclosed in a membrane and the whole cell is transparent.

Shape of Bacteria.

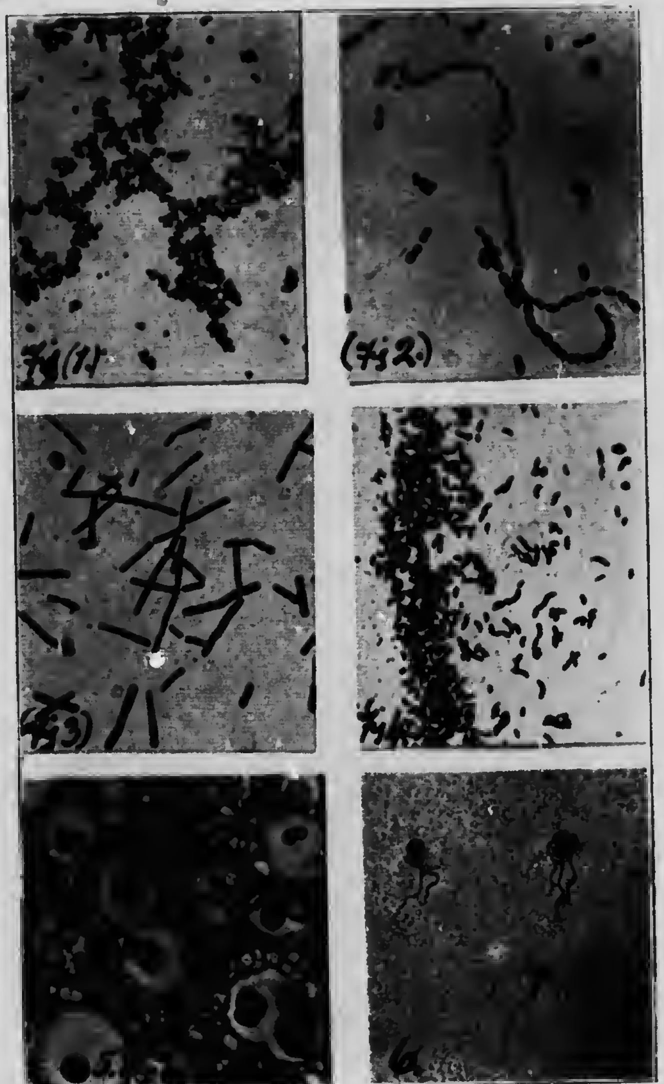
There are four typical shapes of bacteria: (1) spherical forms known as cocci; (2) straight rod forms known as bacilli; (3) spiral forms known as spirilla; and (4) thread forms known as thread bacteria. Bacteria of any one of these four types never change to either of the other types. There are many species of each type.

Method of Bacterial Growth and Multiplication.

Bacteria absorb their food in solution through their cell membrane. The food so absorbed is utilized by the internal protoplasm of the cell, which thus increases in quantity, and following this increase in substance the cell divides in two, each cell being a complete bacterium. These two bacteria continuing to feed, again divide, and thus produce four, and so the development and multiplication goes on. Under favorable conditions of moisture, food and warmth this growing and dividing takes place about every twenty minutes or half hour, so that in twenty-four hours we may get a progeny of ten millions or twenty millions of bacteria, all developed from one bacterial cell. It is this power of rapid multiplication inducing as it does changes in the material in which the bacteria are growing that makes bacteria so important in the economics of life, some of them being beneficial and some injurious.

BACTERIAL MOVEMENT.

Some species of bacteria have the power of motion when placed in liquids. Some of them move about like fish, others wriggle like mosquito larvæ, others glide along with a snake-like motion. These movements can readily be observed when a satisfactory preparation is viewed under the high power microscope. The



Various Types of Bacteria. (Original.)

1. *Micrococcus albus*, magnified 1,000 diameters.
2. *Streptococcus lacticus*, magnified 1,000 diameters. (Lund.)
3. *Bacillus Bulgaricus*, magnified 1,000 diameters. (Lund.)
4. *Spirillum rubrun*, magnified 800 diameters.
5. *Azotobacter chroococcum*, showing capsules, magnified 1,000 diameters.
6. *Azotobacter chroococcum*, showing flagella, magnified 1,000 diameters.

bacteria which have this power of motion are furnished w h delicate little whips called flagella. These flagella project from the body, som ues from the end and sometimes from the sides, and by waving or lashing these flagella the bacteria are propelled forward or backward.

Bacterial Spores.

Some species of bacteria, when the food supply fails them or becomes otherwise unfavorable, go into what is known as the spore condition. That is, the protoplasm within the cell membrane contracts and condenses and around this condensed protoplasm another membrane is produced, which is very tough and resistant. This condensed protoplasm, enclosed in its tough membrane, is the bacterial spore. These bacterial spores are very resistant to drying, heat and disinfectants. Some of them may be boiled for an hour or two without being killed. It is the presence of such bacterial spores on meat and vegetables such as corn, peas, beans, etc., which makes it so difficult to "can" these materials satisfactorily. The spores remain dormant until the conditions around them are satisfactory for germination. Moisture, warmth and food are the conditions which induce germination of the spores. When a spore germinates, the membrane around it breaks open and the protoplasm emerges and forms a growing bacterial cell. This bacterial cell grows and multiplies until conditions again become unfavorable for further multiplication and then the bacterial cells thus formed go into the spore condition. These bacterial spores are very common in soil, dust and on the surface of anything that is exposed to a dusty atmosphere.

Bacterial Capsules.

Some species of bacteria produce soft, gelatinous capsules around the outside of their membrane. It is these bacteria which produce the so-called ropiness in milk and bread. This ropiness is due to the development in the milk or bread of large numbers of bacteria with their capsules, and it is the sticking together of the capsules that makes the milk or bread ropy, slimy and sticky. The gelatinous substance which grows on vinegar and known as mother of vinegar is simply a mass of millions of vinegar bacteria, each one with its gelatinous capsule sticking to its neighb

Places Where Bacteria Are Found.

B found in large numbers wherever any other forms of life exist. One oun cultivated soil will contain millions of them in an active, growing condition. In dust they are present usually in the spore or dormant condition. In natural waters, such as rivers, lakes, ponds, wells, etc., they will be present in varying numbers according to the amount of contamination from soil surface washings and seepage. They are present in immense numbers in all decaying or putrefying organic material, whether of vegetable or animal origin, manure piles, garbage heaps, etc. It is their presence and activities in such material which induces the fermentation, decay or putrefaction which takes place. They are present on dry hay and straw, in considerable numbers, usually in the spore condition. They are present on the hands, face, head and surface of the human body generally, and in immense numbers on the bodies of all animals, flies, and other insects. Any food material, whether cooked or uncooked, which is exposed gets contaminated with them. As a result of this contamination the food is apt to spoil unless used before it has time to spoil. Milk becomes sour or putrid as a result of the development and multiplication of the bacteria which get into it during the milking operations and subsequent handling. Bacteria are thus practically omnipresent.

Kinds of Bacteria.

Just as there are many kinds or species of plants and animals so there are many species of bacteria. The great majority of species are beneficial in their action; some, however, are injurious and amongst these latter are those species which produce the infectious diseases of men and animals, such as tuberculosis, typhoid fever, anthrax, black leg, contagious abortion, etc., and those which produce such diseases of plants as "fire blight" of apple and pear trees, crown gall, soft rot of vegetables and bacteriosis of beans. A different species of bacteria is necessary for each of these diseases.

In addition to those bacteria which cause disease being injurious, there are some which are beneficial in one place but injurious in another. For instance, many of the species of bacteria beneficial in the soil are injurious when they get on to food material, as they bring about the decay or putrefaction of the food, rendering it unfit for use if they are allowed to develop and multiply on or in it. Hence, we refer to some bacteria as friends and others as foes.

For the purpose of further discussion we will group the different kinds or species of bacteria under the following heads:

Group I. Bacteria of the Soil and Manure Pile.
" II. Bacteria of the Water Supply.
" III. Bacteria and Sewage Disposal.
" IV. Bacteria and Food Preservation.
" V. Bacteria of Milk and Milk Products.
" VI. Bacteria of Infectious Diseases of Man and Animals.
" VII. Bacterial Diseases of Plants.

GROUP I. BACTERIA OF THE SOIL.

As previously stated, one ounce of good soil will contain millions of bacteria. They are more numerous in the first foot of soil than at greater depth, their numbers rapidly diminishing below two feet until at four feet very few are found. The function of the soil bacteria is to prepare the plant food present in the soil so that it can be assimilated by the growing plants.

Plant Food Digesting Bacteria.

When fresh manure, green manure, stubble or sod is ploughed in, the plant food which these contain is in a crude condition, and has to be prepared or digested before the growing crop can use it. This preparation or digestion is brought about by various species of the soil bacteria. These soil bacteria may be likened to the digestive juices in the stomach and intestines of man and animals, which prepare the food for assimilation by the body. Unless these digestive agents are present and active, the food is not assimilated. This digestive process in the soil is a very complicated one, taking place in different stages, and different species of bacteria are necessary for each of the different stages.

First, there are the species of ammonifying bacteria which digest or break down the proteid substances and liberate ammonia. The ammonia thus liberated is seized upon by the nitrifying bacteria, one kind of which (nitrous bacteria) changes it to nitrites, and another kind (nitric bacteria) change the nitrites to nitric acid which on combination with sodium or potassium gives nitrates: these nitrates can then be used by growing plants.

Soil Bacterial Cultures. (Original.)

1. Colonies of bacteria of various types growing on solid gelatin medium inoculated from garden soil highly diluted.
2. Test tube cultures of a gas-producing soil bacillus growing in solid sugar gelatin medium.

Notice how the solid gelatin has been split up by the gas produced by the growing bacteria.

In addition to this action on manures, green and otherwise, there is a bacterial action on the minerals of the soil. Growing plants require small quantities of mineral food, and this has to be set free from its combinations in the soil and rendered available before the plants can use it. This action is induced by certain of the soil bacteria, the same species which act on the manures being largely responsible for this work.

Nitrogen-Fixing Bacteria.

In addition to the species of bacteria which prepare the plant food contained in or added to the soil there are other species which add plant food directly to the soil. These are principally the *azotobacter* or nitrogen-fixing bacteria which are able to use the free nitrogen of the atmosphere for their own bodily needs, and as a result of their activities some of the atmospheric nitrogen becomes added to the soil in such a condition that growing plants can use it. Approximately four-fifths of the atmosphere is nitrogen and while plants require considerable quantities of nitrogen in their food supply they cannot use the free nitrogen of the air directly. They can take their nitrogen only in the form of nitrates. In common practice these nitrates are usually added to the soil in well-rotted manures or in nitrate fertilizers, or they are prepared from green and fresh manures by the action of the previously-mentioned classes of bacteria. But the nitrogen-fixing bacteria take the free nitrogen of the atmosphere and so combine it that eventually it becomes incorporated in the soil in such a condition that growing plants can use it.

Legume Bacteria.

There is another class of nitrogen-fixing bacteria that do their nitrogen-fixing when developing in combination with leguminous crops such as all the clovers, alfalfa, vetches, peas and beans.

It has been known for centuries that the soil of fields in which there has been grown a good clover, pea or other leguminous crop is richer after the crop than it was before. Hence the practice of having a clover or other leguminous crop in the crop rotation. Just why a good leguminous crop was beneficial to the soil was not known until a few years ago. It was then found that certain species of bacteria, which came to be known as the *legume bacteria,* entered the roots of the legumes and produced on them little swellings or nodules. Wherever these nodules are present in large numbers on the roots or legumes a good crop is assured. The combination of the legume bacteria with the plant results in fixation of the atmospheric nitrogen which becomes incorporated in the plant tissues. root, stem and leaf, giving a larger and more vigorous plant than is the case where the bacteria are not present.

It has been found that different varieties of legume bacteria are necessary for most of the different legumes. The variety of bacteria good for red and white clover is no good for alfalfa or sweet clover; the variety good for field peas is no good for field beans, and the variety good for field beans is no good for soy beans, and so on with other legumes.

If any particular legume crop has not been growing satisfactorily in any particular field, it is questionable if the right kind of legume bacteria is present in the soil of that field. So, before a satisfactory crop can be grown the right bacteria have to be introduced. For instance, the cultivation of alfalfa is a new practice in many sections. If sweet clover is common in the district it is probable that the right bacteria are there for alfalfa, as the variety good for sweet clover

Legume Plants Showing Influence of Inoculating Legume Seeds with Nitroculture (Legume Bacteria). (Edwards and Barlow.)

1. (A) inoculated and (B) uninoculat[illegible]a plants from a farm in Grey County, Ontario. Regarding the field from which these plants were taken, a[illegible]cultural Representative of the Department of Agriculture who saw the field, writes as follows:—"A part of the field was seeded with seed treated with culture obtained from the Bacteriological Department at the Ontario Agricultural College, Guelph; while the rest of the field was seeded with a better grade of seed, which, however, was not inoculated. There is a good catch of seed all over the field, but that which was from uninoculated seed has not made a very vig[illegible]ous growth, while that from inoculated seed has made a luxuriant growth. In digging, many nodules could be found on the roots of the inoculated alfalfa, but none were on the roots of that which was not inoculated."
2. Red clover seedlings (A) from inoculated seed and (B) from seed not inoculated, both samples grown on the same field at the same time.

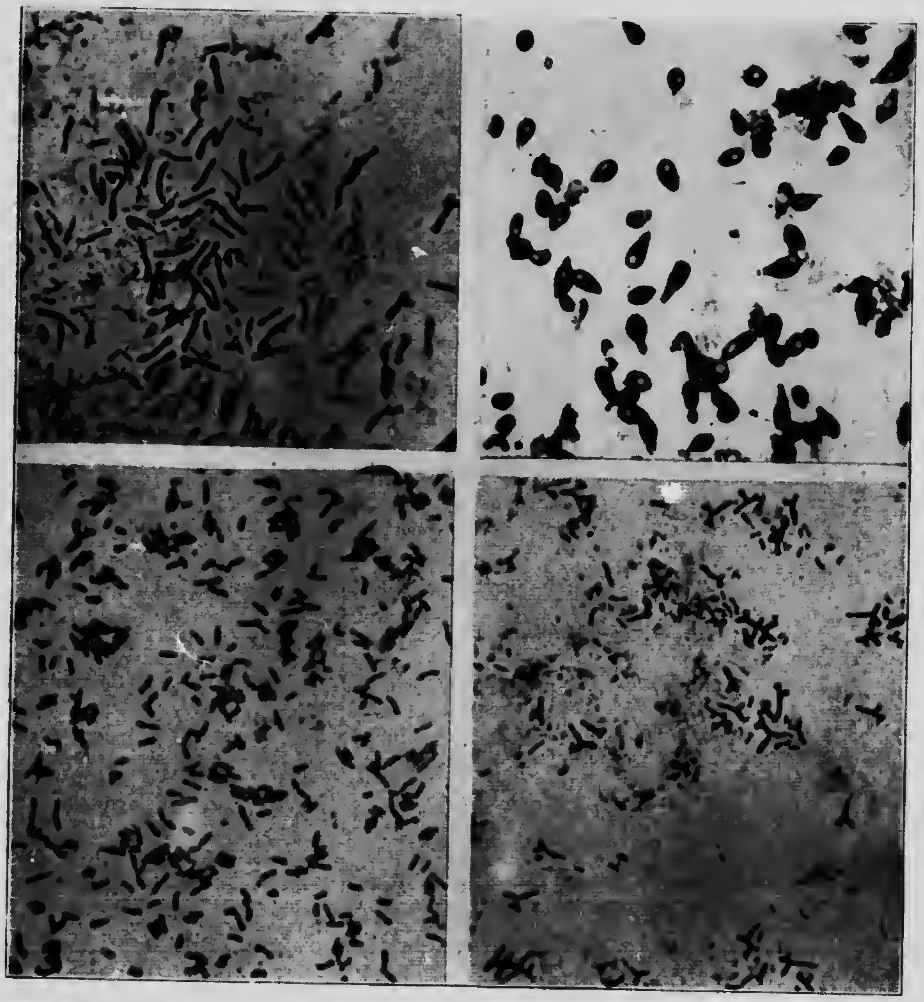
Beneficial Nodules on Roots of Leguminous Plants produced by the Legume Bacteria. (Photo by Barlow.)

1. **Ncdules on a portion of alfalfa root.**
2. **Nodules on field pea root.**

is good for alfalfa. If it is not present, it is doubtful if a good crop will be grown; hence the difficulty often met with in getting alfalfa established in a new district unless the bacteria are first introduced. There are various ways of introducing the bacteria. One is to take a few loads of soil from a field in which the bacteria are present and scatter this over and work it into the field to be treated. This method was the first adopted. It is not practicable, however, in most cases.

Legume Seed Inoculation.

Another way is to inoculate the seed of the legume crop to be sown with a pure culture of the right variety of bacteria. When this is done, the bacteria are



Different Varieties of Legume Bacteria. Stained and magnified about 1,000 diameters. (Original.)

1. **Bacteria from an alfalfa nodule.**
2. **Bacteria from a red clover nodule.**
3. **Bacteria from a field bean nodule.**
4. **Bacteria from a field pea nodule.**

on the surface of the seed when it germinates in the soil and so get into the young roots. These cultures of legume bacteria are prepared in bacteriological laboratories and sold so much per culture. They are known as *nitro-cultures,* or *legume bacteria cultures,* and various other trade names have been given them. The Bacteriological Laboratory of the Ontario Agricultural College was the first to produce these cultures satisfactorily for distribution on the American continent. They are sold from the laboratory for the nominal sum of 25c. each, to cover cost of material, container and postage. Each culture is sufficient for one bushel of seed. Thousands are sent out annually to all parts of Canada on application for the same. Many letters have been received showing that very beneficial results have been obtained from their use, more particularly from those districts where the crop to be inoculated was new. For further information regarding these legume bacteria cultures, apply to the Bacteriological Laboratory, Ontario Agricultural College.

What Soil Bacteria Need to do Their Best Work.

From what has so far been said about the various soil bacteria, it will be gathered that they are friends and not foes of the farmer. They are not only useful but are absolutely essential, and the more there are of them in the soil and the more actively they are working, the better will be the crop returns. We are faced then with the problem of how to encourage their development and activities. To solve this problem we must know the conditions favorable to their development.

1. Oxygen.—First, the beneficial soil bacteria need oxygen, as many of the changes which they bring about are oxidation processes. There is an unlimited supply of oxygen in the air, and if the soil is well drained there will be plenty present in between the soil particles to a depth of two feet for the use of the bacteria. If, however the soil is caked or waterlogged, the necessary oxygen is not available for the bacteria, therefore their development and activity is checked and their elaboration of plant food is prevented. To supply the soil bacteria with their necessary oxygen we must therefore keep the soil well drained and the surface loosened up and pulverized by cultivation.

2. Moisture.—The second requirement of the soil bacteria is moisture. This does not mean saturation or free water such as would induce a waterlogged condition in the soil. So long as the soil is just moist there will be plenty of moisture for the bacteria. Two-thirds saturation is as much moisture as should be present. This moisture should exist as a thin film of water around the individual soil particles, and it is in this film of water that the bacteria live and do their work. There should, however, be no free water between the soil particles, as this would keep out the oxygen. Hence, to have right moisture conditions for the bacteria in the soil it should be well drained to carry off all excess moisture in wet periods, and in dry periods it should be shaded or cultivated where practicable so as to keep a soil mulch on the surface to prevent excessive evaporation.

3. Neutral or Slightly Alkaline Reaction.—A third requisite for the soil bacteria is a neutral or slightly alkaline reaction in the soil. That means that there should be no free acid in the soil, in other words, the soil should not be "sour." The beneficial soil bacteria will not develop where acid is present. The work of some of the soil bacteria includes the production of acid, and if this acid is allowed to accumulate it interferes with further bacterial activities. This acid as it is produced must be neutralized and if sufficient lime or potash is present

Nodule Sections 5 microns thick, stained with analin safranin and gentian violet. Magnified 1,000 diameters. (Original.)

1. Section of a nodule from soy bean root, showing the bacteria as small black specks within the plant cells.
2. Section of a nodule from field pea root, showing the bacteria as irregular-shaped rods within the plant cells.

in the soil, the acid is neutralized as fast as it is produced. If the acid in question is nitric acid and it is neutralized by potash, we get as a result potassium nitrate, which is one of the most valuable nitrate fertilizers, and readily assimilated by the growing plants. If lime is not present in the soil in sufficient quantities to neutralize the acid, then it should be added.

4. Organic Food Substances.—A fourth requisite of the soil bacteria is organic food substances. These are supplied by the sod, stubble, manures, straw, etc., that are ploughed in, and these should be present in fair quantities to feed the bacteria. It is this process of the bacteria feeding on these crude plant food substances that breaks them down or digests them, making them suitable for the growing crop to use them. This action of the bacteria in digesting the crude organic material added to the soil results in the production of humus, which it is so essential should be present in cultivated soils.

BACTERIA OF THE MANURE PILE.

The action of various species of bacteria in manure is just as necessary to prepare it for plant assimilation as is the action of bacteria in the soil. The changes that take place in manure from its fresh to its well-rotted condition are due almost altogether to the action of bacteria aided to some extent by molds.

When fresh manure is added directly to the soil, the plant food which it contains is not so readily available to growing plants as is the case with well rotted manures. The bacteria contained in the fresh manure aided by those present in the soil have to break down the complex organic compounds of the manure into simpler forms, or, as previously described, digest them before the growing crop can use them.

In the case of well-rotted manure, however, most of this digestive process has been completed by the bacteria, and the plant food present is largely in the right condition to be readily used by the growing crop. The rotting or ripening of the manure is mainly the digestive action of the bacteria contained in the manure.

The kinds of bacteria which bring about this action in the manure pile are the same as those which bring about the digestive processes in the soil. But the conditions which prevail in the manure pile are different from those which prevail in the soil, and as a result we are just as liable to have injurious action, resulting in loss, induced by these bacteria as we are to have beneficial action. Consequently, the bacterial action in the manure pile has to be controlled if we are to get best results.

There are large numbers of bacteria in manure when it is produced. These numbers rapidly increase and are added to from the stable floor, the air and surroundings generally, and a rapid fermentation of the manure results. Everyone is familiar with the sharp, pungent, ammoniacal odor which is given off from an occupied horse stall if it has not been cleaned out for a day. This odor is due to the free ammonia which is given off from the manure, liquid and solid, through the rapid action of the ammonifying bacteria. When the ammonia is given off into the atmosphere it is lost, and so this action should be prevented as far as possible.

If the fresh manure is thrown into a pile and the pile is kept well packed and moist the production of ammonia will not be so rapid as to be readily given off into the atmosphere. Most of it, as it is produced, will be seized upon by the nitrous bacteria and changed to nitrites and these nitrites will be changed by the nitric bacteria into nitric acid and finally result in nitrates. It is the presence of these nitrates in well rotted manure that is largely responsible for well rotted manure giving quicker returns than fresh manure when added to the soil.

Fire Fianging in Manure.

Everyone who has had anything to do with horse manure will be familiar with the condition known as fire flanging. This fire flanging means loss, as it destroys the plant food in the manure by a slow burning. The condition of fire flanging is due to a rapid oxidation in fresh manure induced primarily by the digesting bacteria. In order for this to occur, there must be abundant oxygen within the fresh manure pile. This condition exists when the fresh manure is loosely packed and strawy. In such manure the bacteria will induce rapid oxidation which causes a rise in temperature. The temperature will continue to rise until eventually the bacteria which have started it are destroyed by the heat and much of the manure rendered worthless. Therefore to prevent fire flanging the manure pile should be kept well packed and moist for the purpose of excluding excessive quantities of air.

There is not the danger from fire flanging in cow manure or pig manure that there is in horse manure, as these manures are naturally wet and compact. Mixture of these with horse manure, providing the whole is well packed, will thus reduce loss by fire flanging.

GROUP II. BACTERIA AND THE WATER SUPPLY.

All natural drinking waters, such as rivers, ponds, lakes and wells contain many species of bacteria. Other micro-organisms are also likely to be present. Some of the bacteria may be harmful to health, being liable to cause disease, but many of them are not.

The species of bacteria found in drinking waters are divided into three more or less distinct groups, as follows:

Group 1. Natural Water Bacteria.

This group includes a number of species of bacteria which are not harmful to health. They are liable to develop and multiply in water in which there is a minimum of organic matter, but as they cannot cause disease their presence is not sufficient to condemn the water for drinking purposes.

Group 2. Soil Bacteria Found in Water.

In the soil, as previously stated, there are many different species of bacteria. These find their way into rivers, lakes, wells and springs, during rains, particularly flood time, being washed from the soil both in the surface and drainage waters. These bacteria do not live and multiply in the water to any great extent unless there is a considerable amount of organic matter present in the water. They do not produce disease, hence their presence alone in water is not sufficient to condemn the water for drinking purposes, though if they are present in any quantity they

1. *Bacillus fluorescens*, fairly common in well water.
2. *Bacillus subtilis* (hay bacillus), common on hay and in the soil; occasionally found in well water.
3. *Bacillus coli*, common in sewage and in polluted water; the danger signal in water examination.
4. *Bacillus typhosus*—showing flagella. Cause of typhoid fever.
5. Flask of culture media, test-tube cultures, inoculating needles, petri dish cul-high-power microscope. (Edwards.)

indicate either that there is considerable organic matter present, or that there is danger of the water being polluted from soil surface washings, which may have been contaminated with disease-producing bacteria coming from infected persons. Neither of these conditions is desirable.

Group 3. Intestinal Bacteria Found in Water.

In the intestines of man and animals there are certain species of bacteria normally present in very large numbers. These are passed out by the million in the bowel discharges. The most common of these species is the *Bacillus coli*. These bacteria do not multiply to any great extent in natural waters, as the food and temperature conditions are not suitable for their multiplication.

Thus, when *Bacillus coli* or any other species of intestinal bacteria is found in water it is an indication that the water has been recently polluted and is dangerous. *Bacillus coli* itself is not, except under certain conditions, a disease-producing bacillus, but wherever it is found in water there is danger of *Bacillus typhosus* which causes typhoid fever, being present. Many outbreaks of typhoid fever are due to the water supply being polluted with the discharges from either a typhoid patient or typhoid "carrier." A typhoid carrier is one who has had typhoid fever and has got better but has not got rid of the typhoid bacteria from his system. Within his system the bacteria are constantly developing and being discharged. Water, milk, or any kind of food that gets contaminated from such discharge is liable to establish typhoid fever in those consuming the food. Hence, great care is necessary to prevent water and foods from being so contaminated.

Shallow wells are very liable to such contamination unless they are properly located and constructed. They should be so located that surface drainage cannot find entrance and the upper ten or twelve feet of the wall should be impervious to water, thereby forcing all water that enters the well to filter through soil, to a depth of at least ten or twelve feet, a process which aids in purifying it.

Treatment of Polluted Water.

When wells have become polluted from unsanitary seepage or drainage the cause should be found and removed and preventive measures taken so that the trouble should not recur.

The water so polluted should be sterilized before being used for drinking purposes. Sterilization may be accomplished either by boiling the water or by the addition of a suitable disinfectant. The disinfectant most suitable for this purpose is a hypochlorite solution. This hypochlorite solution may be prepared and applied as follows:

Stock Hypochlorite for Water Purification.

1. Mix one half pound of chloride of lime (33 per cent. available chlorine) with one pint of water.
2. Add sufficient water to make one gallon.
3. Dissolve 13 ozs. of sal soda crystals in two quarts of luke-warm water.
4. Add sufficient water to make one gallon.
5. Mix these two solutions in a barrel or crock and allow the milky solution to settle over night.

6. Pour off the clear liquid from the white sediment into a jug and fill into bottles, well stoppered, and keep cool in a dark place. This "stock hypochlorite" will contain approximately the equivalent of 3 per cent. of chloride of lime or 1 per cent. of available chlorine.

Application.—Mix one ounce of this stock solution to five gallons of water that is to be used for drinking purposes. After mixing allow to stand for half an hour before use.

1. A few colonies of bacteria growing on a gelatin plate culture from 1 c c. of a sample soil bacteria. This sample of water was good and fit for drinking purposes. (Original.)
2. A large number of colonies of various species of bacteria growing on a gelatin plate culture from 1 c.c. of a sample of well water submitted for examination. In addition to the ordinary water and soil bacteria, there are many sewage bacteria present indicating that the water was badly polluted and unfit for drinking purposes. Such drinking water is liable to cause typhoid fever. This sample of water was condemned as dangerous. (Original.)
3. Petri dish cultures of bacteria showing bacterial colonies growing on solid gelatin culture medium. (Edwards.)

The solution may be added in small quantities to water after it has been drawn from the well or the quantity of water in the well or cistern may be estimated and the necessary amount of the solution poured direct into the well and stirred in.

Farm well waters in Ontario suspected of being polluted will be tested upon application to the Bacteriological Laboratory, Ontario Agricultural College.

NOTE.—For further discussion on water supply, see Bulletin 267.

GROUP III. BACTERIA AND SEWAGE DISPOSAL.

The satisfactory disposal of human excreta is frequently a troublesome problem both in individual houses in the country, and in dense town or city communities. The excreta contains considerable manurial value, as it is composed almost entirely of organic material in process of decay. It contains millions of bacteria to the ounce, and it is the activities of these bacteria that are responsible for its putrefaction and decay. If allowed to accumulate as in dry closets or outhouses, it becomes a decided nuisance with objectionable odors and serves as a breeding place for flies and other insects. If these closets were kept clean, the contents being removed weekly and buried six inches to a foot beneath the surface of the soil in field or garden, the nuisance would not occur. When the excrement is allowed to accumulate, the action of the various anaerobic species of bacteria within the mass results in the production of the strong smelling gases, whereas if it is not allowed to accumulate but is buried in small quantities just beneath the surface of the soil, the aerobic species of bacteria bring about its decay without the production of the strong odors and its full manurial value is recovered in the soil.

The best and most up-to-date method of sewage disposal for separate houses is by the installation of water-closets and septic tanks, the effluent from the septic tank to be carried to the soil by means of a sub-irrigation tile system, as outlined below.

The septic tank is built of brick or concrete beneath the surface of the ground and is composed of two sections. The first section is known as the settling tank and the second as the discharge tank. The sewage from the house is conveyed by tight-jointed, glazed tile to the settling tank. This tank remains always full of sewage and the solids present gradually settle to the bottom. As more sewage enters, the liquid from this chamber overflows to the discharge tank and collects there until a certain depth has been reached, when the whole contents of the tank are discharged by the working of an automatic valve fixed at the bottom. This discharged liquid is conveyed through tight-jointed tile to the sub-irrigation system of open-joint tile spread out in the soil of the garden, lawn or other convenient area.

In the settling tank there is a very complicated bacterial action. The crude fresh sewage contains many millions of bacteria, some species of which soon die. Others multiply and bring about great changes in the sewage through their digestive action, breaking down the complex chemical substances of the organic material present into simpler substances that are soluble and breaking down the soluble substances to water and gases.

The class of bacteria which do most of this work in the setting tank is composed largely of the so-called anaerobic bacteria. These are certain species which multiply and do their work in the absence of oxygen. They accumulate in large numbers near the bottom of the tank, and it is their function to partially digest the solid materials that settle to the bottom, changing them from the solid to the soluble condition, when they are ready to pass over into the discharge tank in liquid form. In this action, gases such as CO_2 and H_2S are produced, which bubble up to the surface.

In the discharge tank the bacterial action is not so decisive as in the settling tank, for the simple reason that the contents of this tank are discharged once or twice daily. Nevertheless, bacterial action is progressing constantly in the sewage of this tank as it slowly increases in volume to the time when it is discharged.

The class of bacteria most prominent in this tank is composed of aerobic species, *i.e.*, bacteria that require oxygen for their activities. The action of these bacteria is largely a furth[illegible]r breaking down or digestion of the organic matter both solid and soluble still [illegible]esent in the sewage. Their action, however, is not completed in this tank as their maximum oxygen requirement is not possible and the liquid does not stay long in the tank.

Septic Tank Construction for Sewage Disposal. (Original.)

This tank was built to acco[illegible]ate the sewage from two adjoining houses. It was built of one course of brick, [illegible]ced with concrete outside and a concrete top.

1. Settling chamber, partly covere[illegible] into which the inlet tile from the two houses can be seen entering.
2. Discharge chamber, showing the syphon valve and outlet tile leading to a sub-irrigation tile system in the garden.

NOTE.—This tank has been in service three years at time of writing, and has given perfect satisfaction.

As soon, however, as the contents of the tank are discharged into the sub-irrigation tile system, the liquid is slowly absorbed by the soil around the tiles and by capillary action a film of the liquid covers the individual soil particles, and through this thin film the oxygen of the soil air is readily available to the bacteria in the film, enabling them to complete their action in the breaking down of the complex organic substances of the sewage into simple substances. Then the soil bacteria, principally the nitrifiers and members of the same class present in the sewage itself, recombine these elements and simple compounds into other compounds as nitrates, when they may be utilized by growing plants.

The strong soapy water from the laundry should not be discharged into the septic tank, as this would interfere with the action of the bacteria. The water from the bath and wash basins, however, [illegible] be discharged into it without unfavorable results.

For details regarding construction and instalment of water-closet and septic tank system, see Bulletin 267.

The Kaustine System of sewage disposal, recommended by the Board of Health, Toronto, for places where a water-closet is not installed, involves chemical treatment of the excreta which destroys the bacteria and dissolves the solids. As this method is not one in which bacterial action is involved, it does not come within the scope of this bulletin. For particulars regarding the instalment of the Kaustine System, apply to Kaustine Co., 858 Dupont Street, Toronto.

GROUP IV. BACTERIA AND FOOD PRESERVATION.

It is a universally known fact that foods not properly preserved will spoil. They will ferment, decay, putrefy or become moldy. These changes are brought about by the development of bacteria, yeasts and molds on or in the food. If these micro-organisms can be prevented from growing on or in the food it will not spoil. Therefore, the question of food preservation resolves itself into the problem of preventing these bacteria, yeasts and molds from growing and multiplying on or in the foods. This is done in various ways as drying, use of antiseptics or preservatives, and "canning" according to the nature of the food to be preserved.

Bacteria are the micro-organisms mostly responsible for the spoilage of vegetables, cereals, meats and milk, while yeasts and molds are mostly responsible for the spoilage of fruits and fruit juices.

As stated in the early pages of this bulletin, the surface of everything which is exposed to the atmosphere is more or less contaminated with these invisible micro-organisms. But before these micro-organisms can multiply and thus become active in the spoiling of the foods on which they are present, the conditions for their development must be satisfactory.

Preservation of Food by Drying.

The first requisite for the multiplication of these micro-organisms is moisture. Hence, if food materials are sufficiently dried and kept dry they will not spoil. The preservation of certain foods by drying has been practised for centuries, and is a common means of food preservation at the present time. Some foods, such as the cereals, wheat, oats and barley, ripened peas and beans, are naturally dry and do not have to be subjected to any drying proc[illegible] that common in the harvest fields. The flour, meal and other preparations made from them are also sufficiently dry to prevent bacterial development in them, providing they are kept in a dry place. If, however, they are exposed to much dampness and allowed to get wet they soon begin to spoil, as the moisture enables the bacteria that are present to develop and multiply, causing the material to ferment, heat and sour or become sticky. Flour, meal and other uncooked cereal preparations all contain bacteria of different species in considerable numbers. These get into the flour from the exterior of the grains during the milling operations and from the dusty atmosphere. These bacteria remain dormant so long as the material is kept dry, and most of them are destroyed in the baking or other cooking operations to which the material is finally subjected before it is used as food. Sometimes they are not all destroyed in the cooking operations, and then if the material is not used soon it is liable to spoil. This is the principal reason for bread occasionally becoming sour, ropy or moldy.

Dried Vegetables.—The preservation of vegetables by drying has developed in recent years into a large business. The vegetables are cleaned and sliced and the moisture is evaporated in suitable drying chambers. Care has to be taken that sufficient moisture is removed or the material will spoil through the development of the various micro-organisms that will be on the individual pieces. The slicing and drying process kills the vegetable tissue, and so the common decay bacteria can readily grow on it if sufficient moisture is present. This drying process decreases the bulk and weight of the vegetables, thereby facilitating transport.

Stored Roots.—Some healthy roots such as turnips, beets, carrots, parsnips, salsify and potato tubers keep satisfactory if well stored at a low temperature even though they are always covered with the common soil bacteria. If such roots are exposed to dampness and warmth they have a tendency to grow rather than to decay. This is due to the fact that they are composed of living tissue, the root or tuber being simply a store chamber of food material and the common decay bacteria present on such roots cannot affect the sound living tissue. If, however, the life of the roots is destroyed by freezing, or too much heat, then decay will set in as the common soil bacteria will readily develop on the dead root tissues, and there will be plenty of moisture present in the roots to enable the bacteria to grow.

Again, if the roots are not sound, but affected with a disease, such as the bacterial soft rot, at the time they are removed from the soil, then the disease will be likely to spread from the diseased specimens to those touching them until the whole pile is rotted as a result of the development and multiplication of the plant disease bacteria, which have the power to attack living plant tissue when once they gain entrance through the skin.

Dried Fruits.—With dried fruits, such as raisins, prunes, currants, figs, etc., another factor besides dryness enters into consideration. It is not necessary to have these fruits bone dry, as in the case of the cereals, a fair percent of moisture being allowed to remain within them. This is because there is a high percentage of sugar in the fruit, and it is only necessaray to evaporate sufficient moisture from the fresh fruit to ensure this sugar being present in a satisfactory density. When this satisfactory density is obtained, yeasts and molds cannot make use of the moisture present, and therefore cannot grow. If these dry fruits, however, are kept in a damp place they absorb moisture, and this brings about a dilution of their sugar content which enables the yeasts and molds to grow, thus spoiling the fruit by producing fermentation and moldiness.

DRIED MEAT AND FISH.—Preservation of meat and fish by drying has been practised for ages. The Indians preserved their meat (Pemmican) by cutting the deer flesh into strips and exposing it to the sun to dry as much as possible. It is the modern practice, however, to augment the drying of meats and fish by the use of certain antiseptics, such as smoke containing creosote fumes and salt. When these antiseptics are used, it is not necessary to dry up all the moisture present, as the antiseptic used should prevent bacterial development, though it does not kill the bacteria.

PRESERVATION OF FOODS BY CANNING.

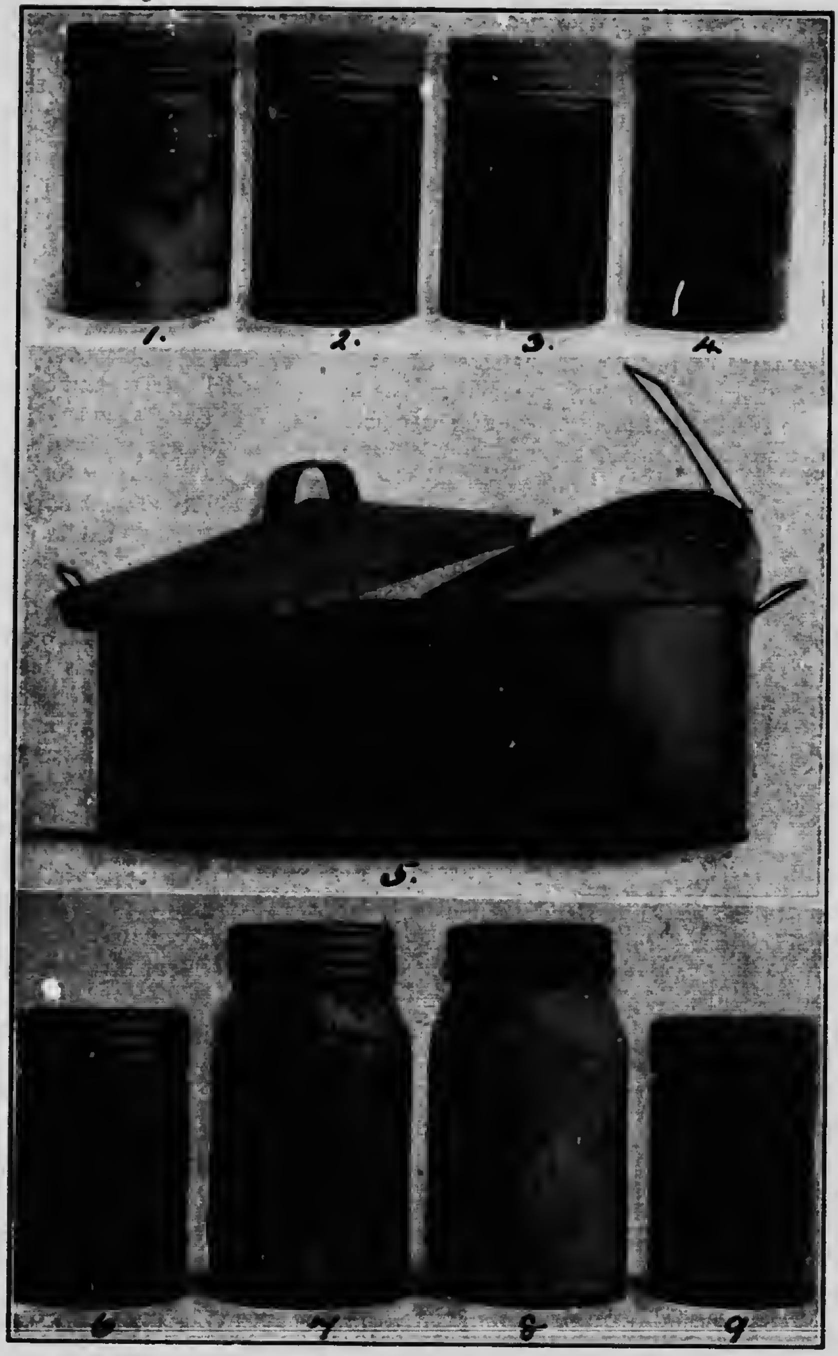
Foods are canned for the purpose of preserving them in their fresh, juicy condition as near as possible. Not only is the moisture originally present in them allowed to remain, but more moisture is frequently added in the shape of syrups.

This method of preservation depends altogether upon two factors; first, killing all the micro-organisms that are present on the foods, and second, preventing other micro-organisms from gaining access to the food after all those present have been destroyed. Fruits, vegetables, meats, fish, and milk, are preserved in great quantities in this way.

CANNING FRESH FRUITS.—The micro-organisms to contend with in the preservation of fruits are mostly, if not altogether, yeasts and molds. With very few exceptions, bacteria cannot grow in fruit juices, owing to the fruit acids that are present. Invisible yeast cells and mold spores are always present on the surface of fruit. They get there mostly from the soil of the orchard where they multiply rapidly, being fed by the juices of the fruit that drops to the ground and is allowed to rot. During cultivation and wind storms many of these yeast cells and mold spores are stirred up into the atmosphere with particles of dust, and so get deposited on the fruit while it is growing.

If soft fruits are allowed to stand for a few days after picking, particularly if some of them have been damaged and the juice extruded, there will be fermentation and molding. This is due to the development of the invisible yeast cells and mold spores that were on the surface of the fruit. These feed on the plant juice and rapidly multiply, and the result of this multiplication is fermentation in case of the yeasts, and moldiness in case of the germination of mold spores. If the fruit is to be preserved any length of time, all the yeast cells and mold spores present must be destroyed and others be prevented from gaining access to the fruit. The destruction of the yeast cells and mold spores present is brought about by the proper application of heat (sterilization) and others are prevented from getting on the material by hermetically sealing the fruit in glass jars, tin cans or other satisfactory containers. Fruit to be preserved should be sound, fresh, not over-ripe, clean, and in case of stone fruits, the stones should preferably be removed. Sterilization may be effected either before or after the fruit is filled into the containers, whether these be sealers or tin cans.

STERILIZATION OF FRUIT BEFORE CANNING.—If the fruit is to be sterilized before filling into the containers, the sterilization process implies cooking or boiling the fruit in a kettle, adding sugar to taste, and then while hot, filling it into hot sealers which have been previously cleaned and sterilized in water heated to boiling, then sealing immediately with rubbers and caps taken direct from scalding water.



1. Pint jar of peaches. 2. Pint jar of raspberries. 3. Pint jar of strawberries. 4. Pint jar of cherries. 5. Wash boiler fitted with perforated false bottom, used for sterilizing jars of fruit and vegetables. 6. Pint jar of butter beans. 7. Quart jar of green peas. 8. Quart jar of young corn. 9. Pint jar of asparagus. (Original.)

If the cooking process of the fruit and the sterilization of the jars, caps and rings has been thorough, and the closure joint is air-tight, the fruit should keep indefinitely until it is opened. After a jar of fruit so preserved is opened, yeast cells and mold spores are liable to get in and so induce fermentation or moldiness, if the contents are not soon used.

The requisite amount of sugar may be added as a syrup after being dissolved in water, equal parts of each, or may be scattered over the fruit in the kettle, mixed in, and allowed to stand over night, by which time sufficient juice will usually be present in the kettle to make boiling satisfactory. The latter method of course ensures a thicker and richer fruit juice than if water were added to the sugar to make a syrup.

The sugar used in the above method is simply for improving the flavor. It does not act as a preservative in the quantities used. If the sugar is to serve as a preservative it must be present in the proportion of at least 40 per cent. of the mass, and the result is jam or thick preserve. When sugar is present in this proportion and well mixed in, yeasts and molds cannot readily grow in the substance, as such a proportion of sugar renders the water unsuitable for absorption by the yeasts and molds. It prevents osmosis.

Sterilization of Fruit After Filling: Cold Pack.—If it is not desired to cook the fruit before sealing up, the fruit may be very satisfactorily sterilized after it is put into the jars. When preserved in this way, the finished product more nearly resembles the fresh fruit than is the case with the fruit that is cooked before filling into jars.

Needless to say, the better condition the fruit is in at the time it is packed, the better will be the finished product. The fruit should be well picked over, not overripe, stems, pits, and unsound specimens discarded, and the fruit rinsed with clean, cold water, and drained. The skin should be removed from peaches and apricots.

The jars, rubbers and caps should be well washed and rinsed. The fruit is then filled into the jars. A syrup of sugar dissolved in water, equal parts of each, is then added to fill up the jar to the brim, the rubber cap and ring put on and closed, but *not* screwed or clamped down tightly, but left a little loose to allow for expansion during the heating process. If the tops are screwed on tightly they are liable to be sprung as a result of expansion of contents when heated.

The jars and their contents are then ready for sterilization. This process implies standing them in cold water, bringing this to a boil, and allowing the jars to remain in the boiling water for 15 to 20 minutes, or placing them in a steamer and steaming for half an hour. An ordinaray wash boiler is a very satisfactory boiling apparatus for this purpose. A false bottom made of strips of wood or perforated sheet iron should be placed inside the boiler so as to raise the jars off the boiler bottom. The jars should then be placed on this false bottom and the boiler about a third or half filled with cold water, the top put on and heated as above described.

Immediately after the heating process, the tops of the jars should be tightly clamped or screwed down, and the jars stood away. If the jars have been properly heated and the caps well screwed or clamped down immediately after so as to make an air-tight joint, the fruit should keep indefinitely, until the jar is opened, as all the yeast cells and mold spores will have been killed and no others will be able to get in.

Canning Vegetables.—Bacteria are the micro-organisms that we have to contend with mostly in the canning of vegetables. It is these which cause putrefaction and decay of green vegetables that are not properly preserved. They are always present on the surface of the vegetables until they are destroyed by heat or some other agent. Yeasts and molds are also liable to be present, but they are much more easily destroyed than the bacteria.

The spores of bacteria, as previously stated, are much more difficult to kill than are yeast or mold spores. Boiling them for one or two hours does not always kill them. Hence it is that more difficulty is experienced in the canning of vegetables than in the canning of fruits. All species of bacteria do not form spores, but there are usually, if not always, some of the spore-bearing species of bacteria on the surface of vegetables.

The vegetables commonly preserved by canning are green peas, beans, corn, asparagus and tomatoes. These should be fresh, sound, clean and not over-ripe.

The cold pack method of putting up gives best results with vegetables, except possibly with tomatoes.

Have jars, rubbers and tops all thoroughly clean and well rinsed.

Green Peas are shelled and blanched (directions for blanching see below) and then filled into the jars, and clean water, salted to taste, is poured in to fill up all spaces. The rubbers and tops are next put on but not screwed down tightly. The jars and their contents are then ready for sterilization. (Directions for sterilization see below).

Green Beans may be packed whole or cut, as most convenient. They should first be picked over, stemmed and blanched, then filled into jars, water, salted to taste, added to cover, rubbers and tops put on but not screwed down tightly. They are then ready for sterilization, as below.

Green Sweet Corn should be cut from the cob and filled direct into the jars. Water, salted to taste, added to cover, rubbers and tops put on, then the jars and contents sterilized, as below.

Asparagus should be picked over and cut to suitable length, then blanched and filled into jars, water, salted to taste, added to cover, rubbers and tops put on, then sterilized, as below.

Tomatoes differ from most vegetables in being very pulpy, having a high water content and considerable acidity. On account of the high water content it is desirable not to add more water than is absolutely necessary.

The tomatoes should be fresh, sound, and fairly ripe. Scald, skin and pack directly into jars. If the juice expressed is sufficient to fill all spaces in the jar when the tomatoes are packed in, so much the better. They will pack better if cut. If sufficient juice is not present to fill all spaces add sufficient water, salted to taste, to cover. Put on rubbers and tops but do not screw down tightly, then sterilize.

Owing to the fact that tomatoes have a fairly high acid content some of the spore-forming bacteria common on vegetables cannot readily grow in the tomato pulp. For this reason it is sometimes easier to sterilize tomatoes than other vegetables. There are, however, some species of spore formers liable to be present that can grow in the pulp, and it is owing to the presence of these that it is advisable to sterilize tomatoes in the same way as recommended for other vegetables, rather than in the way recommended for fruits.

Another way for canning tomatoes is to sterilize them before filling into the jars. This is, perhaps, the most common method practised. It implies cooking the tomatoes and filling hot into hot sterilized jars in the same way as used for fruit.

For canning this way the tomatoes are scalded, skinned, placed in a kettle and boiled for an hour or so with occasional stirring. In addition to destroying the micro-organisms present, this process will drive off some of the water content. The jars, rubbers and tops are sterilized as described for fruit, and the hot pulp is transferred direct to the hot jars, which are then topped and screwed down tightly and placed away.

If all the micro-organisms in the pulp have been destroyed in the cooking process and the jars and tops effectively sterilized, and the joint is air-tight, the tomatoes will keep indefinitely. Otherwise the tomatoes will spoil.

NOTE 1.—*Blanching* implies washing the material in clean, cold water, then placing it in boiling water for two or three minutes and stirring carefully. This removes substances from the exterior of the vegetables that otherwise would tend to give a slimy precipitate in the canned goods. On removal from the boiling water the vegetables should be placed in cold water to cool and get firm before filling into the jars.

NOTE 2.—*Sterilization of Vegetables put up by the Cold Pack Method.*—There are three ways of sterilizing vegetables that have been put p by the cold pack method.

Method 1.—Place the filled jars with loose tops in a boiler half full of cold water, as described for sterilizing fruit. Bring the water to a boil and keep it boiling for two to three hours. Then screw or clamp the tops down tightly while hot, and place the jars away. Occasionally there are bacterial spores present that will resist boiling for two or even three hours. When such are present, the goods will spoil. For this reason we cannot guarantee this method, although it is commonly practised.

Method 2. Place the filled jars in the boiler, half-filled with cold water, bring to a boil and boil for half an hour. Then tighten down the tops, remove from boiler and put on one side to cool. Twenty-four hours later, loosen the tops slightly and return the jars to the boiler and heat for half an hour, as on the previous day. Then tighten down the tops again and remove jars from boiler to cool. Repeat this operation for the third time after another twenty-four hours and then the sterilization should be complete. Tighten down the tops and store away the jars.

This method entails quite a lot of labour, but it is the best and surest method for sterilizing vegetables. The reason for giving three heatings is as follows: The first heating destroys all the mold spores, all the yeast cells, and all the bacteria that are not in the spore condition. It does not kill the bacterial spores, however. During the twenty-four hours that elapse between the first and second heatings many of the bacterial spores present will germinate. After germination the second heating will kill them. Usually all the spores present do not germinate between the first and second heatings, but these will nearly always germinate between the second and third heatings, then these are destroyed by the third heating. These three separate, half-hour heatings, are more effective than the one three-hour heating.

Method 3. For this method steam under pressure is necessary. A strong steam-tight chamber, known as the autoclave or "canner" is used. Into this the filled jars or tins are placed, some water is put into the bottom of the canner and heat applied sufficient to generate steam. When the top is screwed down tightly the steam enclosed under pressure rises to a temperature of 240° to 250° F. This high temperature is maintained for 30 to 45 minutes, by which time all forms of life, including bacterial spores, should be destroyed.

The jars or cans are then removed and hermetically sealed.

The "National Junior No. 1 Canner" has proved itself satisfactory for this method of sterilizing vegetables, meats and fruits.

VINEGAR BACTERIA.

Vinegar is made from alcoholic liquids, such as wine, hard cider, fermented honey, malt and fruit juices by the action of the vinegar or acetic acid bacteria, *Bacterium aceti*, commonly called "mother of vinegar." Wine and cider vinegars are considered the best.

The mother of vinegar is a slimy gelatinous layer that forms on the top of acidifying alcoholic liquids. This layer is composed of millions of vinegar bacteria sticking together by means of their gelatinous capsules.

Vinegar or acetic acid is produced from fermented liquids, as a result of the oxidation of the alcohol present in the liquid. This oxidation may be produced by chemical means, but in usual practice it is due to the action of the vinegar bacteria in the presence of the oxygen of the atmosphere. There are several species of vinegar bacteria, each species producing a somewhat different kind of film from that of the others.

Home Manufacture of Cider Vinegar.—Good hard cider is necessary to make a good sample of cider vinegar. The hard cider may be made from apples by pulping them and straining out the juice and allowing it to ferment in barrels or other convenient receptacles.

The fermentation of the apple juice may be hastened and improved by adding some yeast, as Fleischman's or Royal Yeast, as soon as the apple juice is expressed from the apples.

When the fermentation is complete, that is, when the sugar of the apple juice has all been changed to alcohol, the liquid is ready for the mother of vinegar to change the alcohol to acetic acid.

As the acetification is an oxidation process there must be plenty of air available to the vinegar bacteria. Consequently, the barrel or other receptacle in which the vinegar is to be made should not be filled too full of hard cider.

The best way to proceed is to lay an empty barrel on its side and fix it so that it will not roll. Then bore a hole at each end near the top and one in the middle on the top. The holes in the ends are for the purpose of aeration and the hole in the top is for filling in the cider. At one end near the bottom a tap should be fitted from which to draw off the vinegar when it is ready.

Fill the barrel about a third full of hard cider, using a funnel with a long shaft, through the hole in the top. Then add some mother of vinegar as a starter. If preferred, the mother of vinegar may be added to the barrel before the cider is filled in. The mother of vinegar will then develop as a gelatinous film over the top of the liquid. Care should be taken not to disturb it by shaking the barrel, as the film will fall to the bottom where it will not do good work. After a few weeks a sample should be drawn from the tap to test for strength of vinegar. If the vinegar is sufficiently strong draw off about half of the quantity and then fill in more cider through the funnel. The shaft of the funnel should be long enough to reach down through the film of mother so that when cider is added it will not disturb the film. The barrel should preferably not be more than half full at any time, as this allows the maximum of surface for the film to develop on and so gives the maximum of aeration to the bacteria that constitute the film.

The vinegar may be drawn off from time to time and more hard cider added.

When the vinegar is drawn off, if it is to be kept any length of time it should be filled into bottles and pasteurized. Filtering and clarifying with isinglass improves its appearance, making it bright and clear

Rapid Method (Commercial).—A more rapid method of making vinegar is to have a vat filled with beech shavings. The top and bottom of the vat are filled with perforations. The shavings are first covered with a coating of mother of vinegar slime by running mother of vinegar slowly through the vat from above down and then passing and repassing hard cider through, simply by allowing it to trickle slowly down over the shavings. In course of time the shavings become covered with the mother, then as the hard cider slowly trickles over their surface in a thin stream the bacteria are able to change the alcohol into acetic acid or vinegar by the time it reaches the bottom. If the vat is not working its best, however, it will be necessary to repass the liquid through the vat several times.

The reason for the rapidity of action in this method as compared with the barrel method previously described, is that the hard cider as it trickles slowly over the surface of the shavings is in direct contact with the mother in a very thin stream, and air is present right throughout the vat in between the shavings, so that the oxidation process which the mother induces can be induced at its maximum rate.

GROUP V. BACTERIA OF MILK AND MILK PRODUCTS.

Bacteria play a very important role in the milk and dairy industry. Practically all the natural changes either good or bad that take place in milk from the time it is drawn until the time it is consumed, or otherwise used, are due to the action of the various species of bacteria that get into it, though sometimes yeasts and molds are involved.

If the milk is to be consumed as milk, then most of the changes that take place in it as a result of bacterial action are injurious. Exceptions to this are found in the prepared fermented milk, as Kephir, Koumiss and Bulgarian Milk; in these, however, the bacterial action is controlled and cultures of certain species of bacteria are added to the milk to bring about the desired changes.

Bad Milk.—Everybody knows that if a sample of ordinary milk is kept for a few days, particularly if it is not kept cold, it will sour or become gassy or ropy or putrid. This souring, ropiness, gas production and putrefaction, is brought about by different species of bacteria in the milk. As the changes in the milk which these bacteria produce are injurious and undesirable, everybody who has anything to do with the handling of milk should know how to prevent their occurrence.

In the ordinary methods of obtaining and handling milk it is impossible to prevent some bacteria from getting into it. With proper care, however, a large percentage of the bacteria that ordinarily get into the milk can be prevented from getting in, and with proper handling of the milk the few that do get in can be prevented from producing any marked changes within a reasonable time. It is desirable, then, that those who have to do with the production and handling of milk should know how to prevent, as far as possible, the bacteria from getting into the milk and also how to prevent those that do get in from bringing about the changes which result in the spoiling of the milk.

How Bacteria Get Into Milk.

1. Bacteria from the Udder.—When milk is drawn from a clean, healthy udder it is practically free from any injurious bacteria. A few bacteria are usually present in the teat ducts and also in the milk cisterns of the udder, and so during milking operations some of these pass out into the milk. The varieties of bacteria that are found here, however, do not as a rule bring about any noticeable change in the milk after it is drawn. Consequently, contamination of the milk by bacteria from the interior of the udder, unless the udder is diseased, is usually negligible.

With the exterior of the udder, however, the case is different. Various species of contaminating bacteria are constantly present all over the surface of the udder and considerable numbers of these are shaken off during the milking operations and drop into the pail unless steps are taken to prevent them. One way to prevent these bacteria from getting into the milk is to wipe the udder over with a clean damp cloth immediately before milking. This does not remove many of the bacteria, but largely prevents their falling off during milking. Another method of prevention is to use covered or sanitary milk pails. These prevent many of the bacteria which fall from the udder or other part of the cow's body during milking from getting into the pail.

2. Bacteria From Cow Hairs.—Hairs from the cow's body are heavily infested with contaminating bacteria. Hundreds or even thousands may be present on a single hair. It is seldom that a few hairs from the cow's body, particularly the flanks, do not get into the milk pail during the milking operations unless care is taken to prevent them. An examination of the strainer through which the milk is poured from the pail to the can usually shows a few hairs at least. It is commonly thought by milkers that, providing these hairs are removed from the milk by the strainer, their getting into the milk does not matter. Such an idea, however, is wrong, for most of the contaminating bacteria present on the hairs when they drop into the milk are washed off into the milk during the milking, and these are much too small to be caught by the strainer. Hence care should be taken to prevent cow hairs from falling into the milk. Grooming and clipping the cow's flanks and hind quarters is helpful in this regard, also wiping them with a damp cloth immediately before milking. Such practices, together with the use of the covered or sanitary milk pail should prevent most of the contamination of milk from cow hairs.

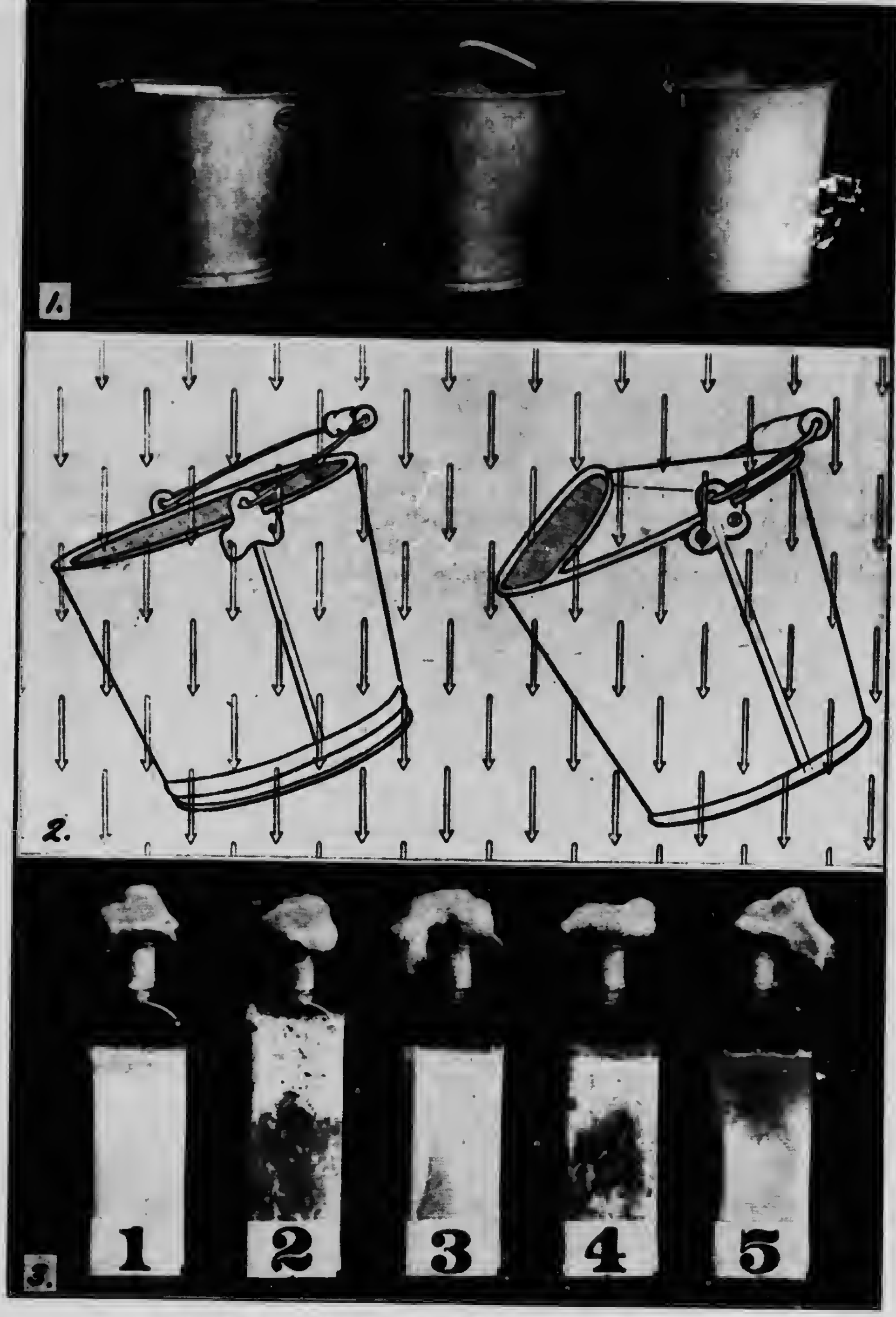
3. Bacteria from Bits of Hay, Straw and Manure.—Every particle of hay, straw and manure will have on it many serious contaminating bacteria, even though the hay and straw appear absolutely clean. These bacteria do no injury to the hay or straw so long as it is kept dry. But as soon as it gets damp

or wet, then they cause it to rot. When bits of hay or straw or particles of manure get into the milk during the milking, the contaminating bacteria are washed from them into the milk, just as in the case of cow hairs, and whilst the bits of hay and straw are removed from the milk by the strainer, the bacteria are not, as they readily pass through the finest strainer used. In this way little bits of hay and straw or bits of manure that drop into the milk from the body of the animal or when feeding or bedding is being carried on, bring about a more or less serious bacterial contamination of the milk.

4. Bacteria from Dust.—As stated in an earlier page of this bulletin, particles of dust in the atmosphere will have on them various species of bacteria, usually in the spore or resting stage. As soon as these get on to any moist food material, they germinate and multiply, feeding on the food material and causing in it various kinds of fermentation. When these bacteria on particles of dust get into milk, they find the most ideal food for their rapid development, and it is this development and multiplication of the bacteria in the milk that changes its character from a desirable to an undesirable condition. Hence care must be taken to prevent dust from getting into the milk. Such stable operations as feeding, bedding and sweeping should not be carried on either during milking or shortly before milking, as they stir up the dust. They should be attended to either after the milking is over or at least an hour before milking, thus giving a chance for the dust to settle before any milk is exposed.

5. Bacteria from Flies.—House flies and stable flies are great carriers of putrefactive and other contaminating bacteria. Hundreds of thousands of these bacteria may be found on one leg of a fly. Flies breed and feed on manure and filth of all kinds, and from these sources they get heavily contaminated with the putrefying bacteria present in such substances. Unfortunately, flies will also feed on good human and animal foods, and when they settle on or fall into such material they naturally contaminate it with the bacteria that they have picked up from manure or filth on which they have previously been. In the summer time they are present in great numbers around stables and manure piles and milk houses, and it is very common for a number of them to get into milk. Hence, as each fly is liable to have hundreds of thousands of bacteria on its legs, mouth and body, when a number of flies get into milk during the milking or handling process, the milk becomes badly contaminated. So every care should be taken to keep flies out of the milk. Manure piles, the breeding place of flies, should not be allowed near the milk house. Windows and doors of milk houses and stable should be screened, milk cans should be kept covered and every other precaution necessary to prevent flies getting into the milk should be taken.

6. Bacteria from Strainers, Milk-Pails, Cans, Bottles and Other Milk Utensils.—Milk strainers, pails, cans, bottles or other utensils that have had milk in them will have a thin film of milk left on their inner surfaces or wherever the milk has been in contact. This thin film of milk, if allowed, will dry on pretty hard. Within this thin film of milk bacteria will be present in large numbers and unless the greatest care is taken to thoroughly wash and then scald such utensils, any milk that is put into them will get contaminated with bacteria from this film. It has been shown many times that milk pails, cans, bottles, and strainers that have not been properly washed and then sterilized either by scalding or steaming are responsible for more bacterial contamination of milk than most other sources of contamination put together. Therefore, the greatest of care



Milk Pails and Milk Contamination. (Photo by Lund.)

1. Ordinary wide-topped milk pail and two covered sanitary milk pails.
2. Diagram showing how the ordinary wide-topped milk pail allows dust, cow hairs, flies, etc., to get into the milk during milking, while the covered sanitary milk pail tends to prevent such contamination.
3. Samples of sterilized milk spoiled by contamination as follows:
   1. By adding a bit of hay.
   2. By adding a pinch of road dust.
   3. By adding a particle of cow manure.
   4. By adding a bit of straw.
   5. By adding a fly.

should be taken to thoroughly wash all milk utensils with brush, warm water, soap, soda or washing powder and then rinse out with clean hot water and follow by scalding or steaming and allowing them to air dry in a dust-free atmosphere. If cheese-cloth strainers are used these should be well washed and boiled **after** each time of use.

7. Bacteria from Milking Machines.—Milking machines were introduced largely as a labor-saving device. It was also thought that they might reduce the bacterial contamination of milk, as they offered no chance for the bacteria of the atmosphere, dust, hay, straw, flies, hairs, etc., to get into the milk during milking. General experience has shown that however much they may reduce labor in milking they do not reduce bacterial contamination of the milk unless they are properly attended to. Frequently machine-drawn milk is worse contaminated than hand-drawn milk. As a matter of fact, in some districts of Ontario, creameries and cheese-factories have refused to take in milk drawn by milking machines, as they found they could not make good products from such milk on account of its high bacterial content.

An investigation carried on in one of these districts by Mr. T. H. Lund, of the Bacteriological Department of the Ontario Agricultural College, showed that the trouble was due to the improper care of the milking machine, particularly the tubes and cups which were not being properly cleaned and sterilized. The trouble was found to be largely in connection with the disinfectant solution in which the tubes and cups were placed after use. In a number of cases the solution was found to have no disinfectant properties whatever; in fact there were large numbers of living contaminating bacteria present in the solution which resulted in the tubes being worse when taken out than when put in. The milk that was next drawn through these tubes would be very badly contaminated. In some cases it was found that the so-called disinfectants used in preparing the solution were not satisfactory. In other cases it was found that though the disinfectant might have been satisfactory at first, the solution had been used so long that it had lost its disinfectant power. In some cases simply a salt brine was used. This is by no means effective, as it will not kill bacteria and will only prevent their growth when in very high concentration. In other cases a handful or two of hydrated lime had been thrown into the vat. In these samples the bacteria content was very high, as this lime had no disinfectant power. Milking machine tubes and cups placed in this supposed disinfectant solution came out worse contaminated with bacteria than when put in.

In caring for the tubes of a milking machine it is necessary to have a satisfactory disinfectant solution in which to place them between milkings. This is necessary because the interior of the tubes during milking gets coated with a thin film of milk in which bacteria will multiply unless it is removed. It is not so simple a matter to remove this film of milk from the interior of the tubes as it is to remove the film of milk from milk pails or cans in the washing and scalding process to which they are subjected. Hence, after the tubes have had a good washing, as it is not possible to scald them satisfactorily, they must be sterilized some other way. This is done by placing them in a vat containing a suitable disinfectant.

The following method of preparing a disinfectant solution and caring for milking machines is recommended after having been thoroughly tried and proven to be reliable:

Chloride of Lime Solution for Disinfecting Milking Machine Tubes, Teat Cups, Etc.—One lb. chloride of lime (full strength 33 per cent. available chlorine).

Ten lbs. (1 gallon) water; mix in enamel pail, crock or wooden tub.

Allow to stand two to three hours with an occasional stir.

Pour or syphon off the clear supernatant liquid and add sufficient water to make 100 lbs.

Immerse tubes and teat cups in this solution. It will be good for about two weeks in summer and three weeks in winter. As long as there is available chlorine it is effective.

Cleaning and Sterilizing the Milking Machine.—The metal parts of the machine should be thoroughly washed and scalded each time after use, and then be put in a clean place.

The teat-cups and tubing should be fitted on to the machine and well rinsed out before and after use every time.

Warm water should be used for rinsing before milking to remove all traces of the chloride of lime.

Warm water and washing powder should be used first after milking, and then hot water before putting the tubes in the sterilizing solution again.

All teat-cups should be taken apart at least once a week and given a thorough scrubbing with hot water and washing-powder, and the tubing well scrubbed out with the brushes provided. They should then be rinsed in hot water before putting together and returning to the chloride of lime. If this could be done twice a week, so much the better, but it must be done at least once a week if satisfactory results are to be obtained.

8. Bacteria from Hands and Clothes of Milker.—The hands of the milker should be well washed and dried before milking, otherwise gross contamination of the milk from the hands is liable to occur. Clean dustless clothes should be worn during milking. Washable overalls and jackets in case of men and washable dresses or overalls in case of women milkers are strongly recommended.

The foregoing eight sources of contamination of milk are the most common. There are others, as for instance, the water in the cooling tank may be badly contaminated, though this should not be the case. Drops of this water getting slopped over the open tops of the cans of milk would cause contamination of their contents. This is how many cases of ropy milk get established.

How to Prevent Bacteria from Spoiling the Milk.

Even after all reasonable care has been taken to prevent bacterial contamination of the milk as outlined above, some contamination will occur, that is, a few bacteria will have got into the milk in some way or other. If these are allowed to multiply in the milk they will spoil it.

The best way to prevent their rapid multiplication in the milk is to chill it immediately in the cooling tank and keep it cold until used. A small amount of bacterial multiplication will take place, even at refrigeration temperatures, and this will show itself in the condition of the milk in course of time. But milk that has been obtained under clean conditions and has been kept cold should be in excellent condition even after forty-eight hours.

Summary of Milk Contamination Preventive Measures.

Prevent dust, cow hairs, bits of hay, straw, and manure, flies and drops of dirty water from getting into the milk during milking operations as outlined above. Thoroughly clean and sterilize all pails, cans, bottles and other utensils. Cool the milk at once down to refrigeration temperature and keep it cool and covered until used.

BACTERIA AND THE DIFFERENT FERMENTATIONS IN MILK.

LACTIC ACID CURDLING.—The lactic acid fermentation of milk is brought about by the action of the lactic-acid-producing species of bacteria on the milk sugar. As a result of this action lactic acid is produced and this combines with the calcium, leaving the casein free and thus producing the curd.

There are quite a number of lactic-acid-producing species of bacteria. The most common is the one usually referred to as the lacti cid bacillus, known also as *Bacterium lactis acidi* and *Streptococcus lacticus*. This is the species that gives a desirable curd and is used in the culture starters for butter and cheese-making. It is a small oval or round bacterium sometimes occurring in chain formation.

BULGARIAN MILK.—Another species is the so-called bulgarian bacillus, or *Bacillus bulgaricus*. This is a large rod bacillus and produces a very high acidity in milk if cultivated properly. It is used to produce the so-called Bulgarian milk which is often recommended for certain digestive troubles.

GASSY CURD.—Another type of lactic-acid-producing bacteria is represented by the colon bacillus known as *Bacillus coli*, being found in large numbers in the intestines, particularly the colon, of man and warm-blooded animals. This bacillus produces gas as well as acid. *Bacillus lactis aerogenes* is another acid and gas-producing species common in manure. These bacteria that produce gas as well as lactic acid are undesirable types in milk.

SWEET CURDLING OF MILK.—Sometimes milk will coagulate or curdle with a sweet or soft curd, something like the curd which is produced by the action of rennet. There are several common species of bacteria found on hay, straw, dust, manure, flies and cow hairs, that have the power to produce this soft curd. These bacteria produce an enzyme ery similar to rennet that acts directly on the casein and albumen of the milk, causing the so-called sweet curd. Unfortunately, these bacteria produce another kind of enzyme which induces putrefaction of the milk, consequently this type is very undesirable.

SLIMY FERMENTATION—ROPY MILK.—The condition of milk known as ropiness or sliminess is due to the development in the milk of certain species of bacteria that produce gelatinous capsules. The most common of these species in milk is *Bacterium viscosis*, and this is responsible for most of the trouble met with in outbreaks of ropy milk. This bacterium is quite common in water, wells, cisterns, and cooling tanks, particularly in the summer time. Anything on which this water gets splashed will thus get contaminated with the ropy milk bacterium. This bacterium will readily grow in milk at low temperatures, so that milk that is contaminated with it, even if kept cold, will be liable to become ropy. Consequently, care should be taken to prevent contamination of the milk from any of the sources of milk contamination previously referred to, as these may be contaminated with the ropy milk bacterium as well as with other bacteria.

ALCOHOLIC FERMENTATION OF MILK.—The alcoholic fermentation of milk is induced mostly by certain varieties of yeast which have the power to ferment the milk sugar and from it produce alcohol and carbon dioxide. The common varieties of yeast used in breadmaking, beer, wine or cider manufacture cannot ferment milk sugar, and so will not cause an alcoholic fermentation in milk unless some other sugar, as ordinary cane sugar, is first added.

There are a few species of yeast, however, that have the power to ferment milk sugar, and these occasionally get into milk from the air and contaminating substances, with very undesirable results to the milk unless a fermented milk is wanted.

Kephir is a fermented milk drink made by putting the so-called Kephir granules into a sample of milk, corking it up tight and allowing it to stand in a warm place to ferment. The Kephir granules are simply masses of milk-sugar fermenting varieties of yeast mixed together with lactic-acid-producing bacteria. The lactic-acid bacteria give a pleasant acid taste, while the yeast produces a small amount of alcohol, thereby modifying the flavour, and also carbon dioxide gas, that makes the liquid effervescent if the container is well corked. Sometimes the Kephir granules get contaminated with other varieties of bacteria and yeasts to such an extent as to spoil the fermentation and produce bad flavors.

PASTEURIZATION OF MILK.

Pasteurization of milk was first instituted to prevent the spread of tuberculosis by milk. It is now used to prevent also the spread of the other infectious diseases that may be carried by milk, also to improve the keeping qualities of milk.

Milk that has been properly pasteurized will have all the common disease bacteria that might have got into it effectively destroyed. Hence, if the process of pasteurization does not interfere with the natural properties and food value of milk, its practice should reduce the outbreaks of infectious diseases.

Unfortunately there is at present no generally recognized or legal standard of pasteurization. The term "pasteurization" is very loosely applied to the heating of milk to various temperatures for varying lengths of time. As wide a range of temperatures as from 140°F. to 190°F. have been variously recommended, and length of time of exposure to heat varying from a moment to two hours. Consequently, so-called pasteurized milk may have a wide range of food values and safety from disease, dependent upon the method of treatment to which it has been subjected.

Milk that is raised much above 150° F. will have something of a cooked flavor, and some of its desirable enzyme properties destroyed. Consequently, so far as the food value of the milk is concerned, it is not desirable to raise the temperature of milk much above 150° F.

It has been repeatedly shown that milk raised to a temperature of 145° F. for twenty to thirty minutes will have all the disease bacteria in it destroyed, and 98 to 99 per cent. of other bacteria also, and the food value of the milk will not be interfered with, and the flavor will be improved rather than injured. Consequently this method of pasteurizing milk is recommended as giving the best results all round.

Milk for pasteurization should be fresh at the time it is pasteurized. If not, the bacterial action that has already taken place in it will have an injurious action on it. After pasteurization, the milk should be rapidly cooled and kept cold until consumed. It should be preferably pasteurized in the bottles or containers in which it is to be kept until consumed, and should be used within forty-eight hours of pasteurization. The bottles or other containers into which the milk is put before pasteurization should have been well washed and thoroughly sterilized before the milk is put in them. Any departure from any of these conditions of treatment will result in an inferior product.

Unfortunately, those who are responsible for our commercial pasteurized milk supply do not always carry out these conditions; consequently, some of the pasteurized milk on the market is not what it is claimed to be so far as safety and quality are concerned. It is very desirable that a legal standard of milk pasteurization be established and enforced.

Milk and the Spread of Infectious Diseases.—A number of the infectious diseases are liable to be spread by milk. The following are the most common of these: tuberculosis, diphtheria, typhoid fever, diarrhœa, summer complaint, infant cholera, dysentery, scarlet fever and sore throat.

In order for the milk to spread any one of these diseases it must first of all be contaminated either directly or indirectly from a case of the disease.

Milk that is drawn from tubercular cattle is liable to have the bovine variety of the tubercle bacterium present in it that may set up tuberculosis in children, also in calves or hogs that are fed on it. Milk that is contaminated as a result of being handled by a consumptive patient is liable to spread the disease amongst humans. *Bacterium tuberculosis,* however, does not multiply in the milk, so that the number of tubercle bacteria found in milk at any time is no more than the original contamination.

With the other diseases mentioned, however, the bacteria which cause them do multiply in the milk. Therefore, any one suffering from, or having anything to do with patients suffering from diphtheria, typhoid fever, diarrhœa, dysentery, scarlet fever, summer complaint, infant cholera, or sore throat, should not have anything to do with the handling of milk, as they are liable to contaminate it with the bacteria which cause these diseases, and when once a few of the bacteria get into the milk they will multiply therein, thus making it very dangerous to the consumers. A large number of outbreaks of these diseases have been traced to a contaminated milk supply where some one individual suffering from one of these diseases has had something to do with the handling of the milk and thus caused its contamination with the bacteria responsible for the disease.

BACTERIA AND BUTTER.

In the manufacture of butter, bacteria are closely associated with the quality of the product, either for good or bad. The flavor or taste of the butter is due very largely to the bacterial action that takes place mostly in the cream before churning, but also to some extent in the butter after it is made.

From what has been previously said about the numbers and kinds of bacteria found in milk, it will be readily understood that there will necessarily be considerable numbers of bacteria in cream whether it be obtained from the milk either by gravity process or by the separator. The number of bacteria in cream is frequently higher than that of milk, particularly in gravity cream, as the fat globules, of which the cream is composed, on rising to the surface, carry with them from the milk considerable of the bacteria.

It is the action of some species of these bacteria that causes the souring or ripening of the cream so desirable for improving its churning properties and also the flavor of the butter. These are the lactic-acid-producing species of bacteria that change some of the milk sugar to lactic acid, and thus bring about the souring of the milk or cream and also produce most of the delicate flavors and odors characteristic of good butter. Other species of bacteria are liable to be present, however, that will give an undesirable flavor to the butter, making it strong or somewhat rancid, fishy, or turnipy in flavor. These latter conditions are usually due to the milk having been badly contaminated before the cream was separated. Thus it will be seen that if we are to get good-flavored butter, the milk from which the cream is obtained must be clean and as free as possible from bacterial contamination.

Cooling Cream.—Another factor that is liable to exert a considerable influence on the bacterial content of the cream is the temperature at which the cream is kept after it is separated from the milk. It is just as necessary to keep the cream cold after it is separated as it is to keep milk cold. Immediately after separation, therefore, the cream should be cooled down in a cooling tank and kept cold until delivered at the creamery. The low temperature will be unfavorable to the development of most of the bacteria present in the cream, particularly the undesirable kinds, and thus prevent the cream from spoiling.

LACTIC CULTURE STARTERS.

In order to control the ripening process of the cream so as to get a uniform product of butter day after day, many creameries use a *lactic culture* for their cream ripening. This is simply a quantity of milk that has first been pasteurized and then soured by the growth in it of a culture of good lactic-acid-producing bacteria. This lactic culture is obtained first from a lactic culture starter, which is a preparation, sometimes in liquid and sometimes in powder form, which may be obtained from the Bacteriological Laboratory of the Ontario Agricultural College for 25 cents, or from commercial bacteriological laboratories such as Ericcson's, Hansen's or Parke Davis' for 50 cents or 75 cents. These lactic culture starters are simply cultures of good lactic-acid-producing bacteria mixed with various substances, as corn starch, that will keep them in a satisfactory condition for some time. To get a lactic culture for use in cream ripening, one of these starters is mixed into a quart of pasteurized milk and placed at 20°-25° Centigrade until the milk curdles. The curd should have a pleasant acid flavor, and have no gas bubbles and very little, if any, extrusion of whey. This curd, if satisfactory, may be propagated further in a larger quantity of milk, such as will be sufficient to act as a starter for whatever quantity of cream is to be ripened. Before adding the culture of sour milk to the cream a portion of it should be set aside in a clean cool place to use as a starter for the next lot of cream. In this way when once a good culture starter has been obtained it may be carried on by such methods of propagation for months or years with proper care. By this method of ripening cream a more uniform quality of butter is obtained from day to day, particularly if the cream is pasteurized before the culture starter is added.

Washing Butter.—After churning, the butter should be well washed to remove, as much as possible, the film of buttermilk from around the butter granules.

as if this is incorporated in the butter it offers a chance for undesirable species of bacteria to develop and thus bring about bad flavors.

Butter fat after it has been well washed is not a satisfactory food substance for bacteria, hence the bacterial content of butter, though very high when the butter is just made, rapidly diminishes on storage. The bacteria which live longest in the butter, however, are mostly the undesirable kinds.

Bacteria and Cheese.

Bacteria play an important role in the manufacture and ripening of cheese. They may have either a beneficial or an injurious effect on the cheese, according to the kinds of them that predominate in the cheese and the conditions under which it is kept during ripening. Molds and yeasts are also much involved, for better or for worse, in the manufacture of the various kinds of cheese found on the market, certain molds being necessary for the production of certain kinds of cheese, particularly the soft cheeses as the Roquefort and Cammembert types. However, it is not our intention in this bulletin to go into a detailed description of the manufacture of the different kinds of cheese with an account of the different micro-organisms that are used in connection therewith. We shall confine our few remarks largely to the part that bacteria play in the manufacture of Cheddar cheese, which is the kind most commonly manufactured in Canada.

Good Cheese.—To get a good Cheddar cheese it is desirable first of all to have milk that is not contaminated with putrefying or gas-producing bacteria. Hence the milk for cheese manufacture should be produced and handled under clean conditions to prevent undesirable contaminations, such as those described previously in connection with milk and butter.

While the milk should be as free as possible from putrefying and gas-producing bacteria, it should contain large numbers of the lactic acid bacteria. These may be added to it in the shape of a lactic culture such as described for butter.

The lactic acid which these bacteria produce is beneficial to the cheese in several ways. First, it helps the rennet in the necessary coagulation of the milk. Second, it has a favorable action on the packing of the cut pieces of curd in the press. Third, its presence is necessaray to aid the pepsin of the rennet to digest, or render soluble, the otherwise indigestible or insoluble proteids of the cheese in the process of ripening. Fourth, it tends to preserve the cheese from putrefaction, as the putrefying bacteria will not multiply in an acid substance. Fifth, it causes the production of much of the desirable flavor to the ripened cheese.

Bad Cheese.—Floating curd or gassy cheese, bitter-flavored, fruity-flavored, or otherwise bad-flavored cheese, is due in practically every case to the milk from which the cheese is made having been contaminated with various species of bacteria and yeasts in any of the different ways mentioned under milk; that is, from dust, or bits of hay, straw, manure, flies, dirty water, unclean hands or utensils. Consequently, those who supply milk to the cheese factories should take every precaution to prevent such contaminations, and those in charge of the factory should see to it that all cans, vats and other utensils be well cleaned and scalded before use.

If the whey is returned to the milkmen it should first be pasteurized, preferably in the whey tank, by turning in live steam. Many cases of bad cheese have been traced to contamination from the whey drawn from the whey tank without its being heated and taken home in the cans used for hauling the milk. Such a practice so heavily contaminates the cans that it is a difficult matter on most farms to effectively clean and sterilize them before the next lot of milk is put into them.

GROUP VI. BACTERIA OF INFECTIOUS DISEASES OF MAN AND ANIMALS.

The bacterial or infectious diseases of man and animals are the worst diseases that we have to contend with. They are transmissible from one person to another, and so spread through the community unless proper steps are taken to control them. Each of these diseases is caused by a different species of bacteria or other micro-organism. When these disease-producing bacteria gain entrance to the system they have the power to grow and multiply there, feeding on the body juices, and the result of this growth and multiplication is the particular kind of sickness characteristic of each different disease.

Typhoid fever, dysentery, tuberculosis, leprosy, diphtheria, smallpox, scarlet fever, mumps, typhus fever, infantile paralysis, epidemic-cerebro-spinal-meningitis, gonorrhœa, syphilis, influenza, cholera, and plague, are some of the most dangerous of these diseases which attack man. Hog cholera, anthrax, blackleg, tuberculosis, infectious abortion, foot-and-mouth disease, glanders, pleuro-pneumonia, chicken cholera, white diarrhœa of chicks, and blackhead of turkeys, are some of the most dangerous of the infectious diseases affecting animals and birds.

TYPHOID FEVER.

Typhoid fever is an infectious disease affecting man only. It is caused by *Bacillus typhosus* gaining entrance to the intestines usually through contaminated foods or water. On getting established in the intestines the bacillus rapidly multiplies, penetrates the intestinal walls and so gets established in the lymph glands and blood, by which time the fever will be at its height. Millions of the bacilli are produced in the body and many of them are given off in the body discharges, both urine and fæces. It is these discharges which are responsible for the disease being spread as an epidemic. Consequently, the patient should be isolated, and the greatest care is necessary in attending to a typhoid patient to see that all bodily discharges are disinfected immediately, preferably before they leave the sick-room. This may be done by adding a five per cent. solution of carbolic acid in equal quantity to the discharge, well mixing, and allowing to stand for several hours before disposal. In place of carbolic acid a one per cent. solution of chloride of lime (bleaching powder, 25-33 per cent. available chlorine) may be used in the same way. Soiled linen and utensils should be well sterilized by boiling. The attendant should be most particular to wash hands in a satisfactory disinfectant before leaving the sick quarters. The attendant should not prepare foods for other people.

Persons exposed to typhoid fever should be vaccinated with anti-typhoid vaccine. This vaccination requires two treatments. The vaccine is injected into the muscle tissue of the arm or breast with a hypodermic syringe. The vaccine is composed of a culture of typhoid bacilli that have been killed. On being injected into the body a resistance to typhoid is produced. The first treatment is with a dilute vaccine which prepares the body to take the second treatment with a stronger vaccine. The second treatment is given about ten days after the first.

Two other forms of typhoid fever are recognized and these are known as paratyphoid A and paratyphoid B. These are caused by different species of bacilli which are closely related to the *Bacillus typhosus.* Paratyphoid A is common in India and paratyphoid B common in Germany. The antityphoid vaccine prepared from cultures of *Bacillus typhosus* will not protect against paratyphoid. Either a separate vaccine or a mixed vaccine of the different species of bacilli has to be used.

Dysentery.

Bacillary dysentery is caused by the dysentery bacilli, and amœbic dysentery is caused by the dysentery amœba. This is an intestinal disease resulting in acute diarrhœa, pain and weakness, varying in acuteness, and sometimes fatal. It is spread in much the same way as typhoid fever, by contaminated foods and water. The bowel discharges of patients contain large numbers of the causal organism, and so the same care regarding their disposal as described for typhoid fever should be practised.

Infantile Diarrhœa is a very similar disease, and is contracted by bottle-fed infants usually through contaminated milk. This trouble may be guarded against by proper pasteurization of the milk. Unfortunately, commercially pasteurized milk cannot always be depended upon as being satisfactory. Therefore, we strongly recommend that milk for infant feeding be pasteurized in the home daily. The milk to be pasteurized should be fresh. The bottle or can containing it should be thoroughly cleaned and scalded before milk is put into it. The bottle or can of milk should be stood in a pot of cold water, and a clean thermometer placed directly into the milk. The pot should then be placed on the stove, and the temperature of the milk raised to 145° F. This temperature should be maintained for twenty minutes by regulating the application of heat. The temperature of the milk should not be allowed to go over 150° F., and should be kept as near as possible to 145° F. for the twenty [illegible]tes. The milk should then be removed and chilled immediately by being sto[illegible]d running water or ice water and kept cold until used. It should be used [illegible]venty-four hours.

Tuberculosis.

Tuberculosis is a slowly-developing disease affecting man, animals and birds. It is caused by *Bacterium tuberculosis* gaining entrance to the body and multiplying in various of the body tissues where it produces the tubercles characteristic of the disease.

Bacterium tuberculosis is a very small microscopic organism, appearing under the high-power microscope as a thin rod, straight or slightly bent, sometimes granular. It varies in length, [illegible]y from two to five microns, i.e., from 1/12,000 to 1/5,000 of an inch, and is about 0.3 microns, or 1/17,500 of an inch in thickness. It is present usually in large numbers in tubercular tissues, and can readily be demonstrated by means of proper bacteriological technique.

There are three recognized varieties of *Bacterium tuberculosis*: (1) ***Human,*** which causes tuberculosis in man; (2) *Bovine,* which causes tuberculosis in cattle, swine and, sometimes, man; (3) *Avian,* which causes tuberculosis in birds, but which has not been proven to be a common cause of tuberculosis in man or the domestic animals.

FORMATION OF TUBERCULES.—When *Bacterium tuberculosis* gains entrance to the body tissue it feeds on the body juices surrounding it and multiplies sometimes slowly and sometimes rapidly. While so developing, it produces a toxin or poison which acts on the tissue cells surrounding it, thus causing a local disturbance, finally resulting in degeneration and death of the tissue cells affected. A mass of such cells constitutes a tubercle. From such a tubercle the bacteria pass in the blood or lymph stream to other parts of the body and produce more tubercles.

A tubercle is thus a mass of degenerated or dead tissue cells caused by the development of *Bacterium tuberculosis* within the tissue, and as the tubercles enlarge and multiply, following the multiplication of the bacteria, the organ affected is slowly destroyed.

The tubercles thus formed are usually pale yellow in color, sometimes cheesy, sometimes fibrinous, sometimes gritty, and sometimes pus-like in texture. They may occur in any of the body tissues, being commonly found in the lungs, liver, spleen, glands, intestines and bones.

DISTRIBUTION.—Tuberculosis exists in all civilized countries. In the human race about 15 per cent. of all deaths are due to this disease. It is widely prevalent among cattle and hogs, conservative estimates placing the number at 10 per cent. to 15 per cent. It is increasing in extent in cattle, hogs, and fowls.

DISSEMINATION.

I. Human to Human:

1. Respiration—Dried sputum from a patient. Discharges from the lungs should be received into cloths or paper cups and immediately burned, or into metal or glass cups and disinfected by submerging cups and contents in boiling water, or by chemical disinfectants.
2. Ingestion—Food prepared by a tubercular patient, contaminated by sputum, urine and fæces. Milk handled by a tubercular patient. Drinking cup table utensils, etc., used by both tubercular and healthy persons.
3. Ante-natal—This occurs rarely.

II. Bovine to Human:

A. By Ingestion.

1. Meat—Infection in this way rarely occurs, unless the meat is consumed raw.
2. Milk—Bovine tuberculosis is transmissible to children or to invalids. It is believed that ten per cent. of deaths from tuberculosis in children are due to bacilli of bovine origin. The germs gain entrance to the milk from the udder of the diseased cow, or through milk contaminated with fæces from cases of intestinal tuberculosis in cows.

B. By wounds, e.g., in post-mortem examinations.

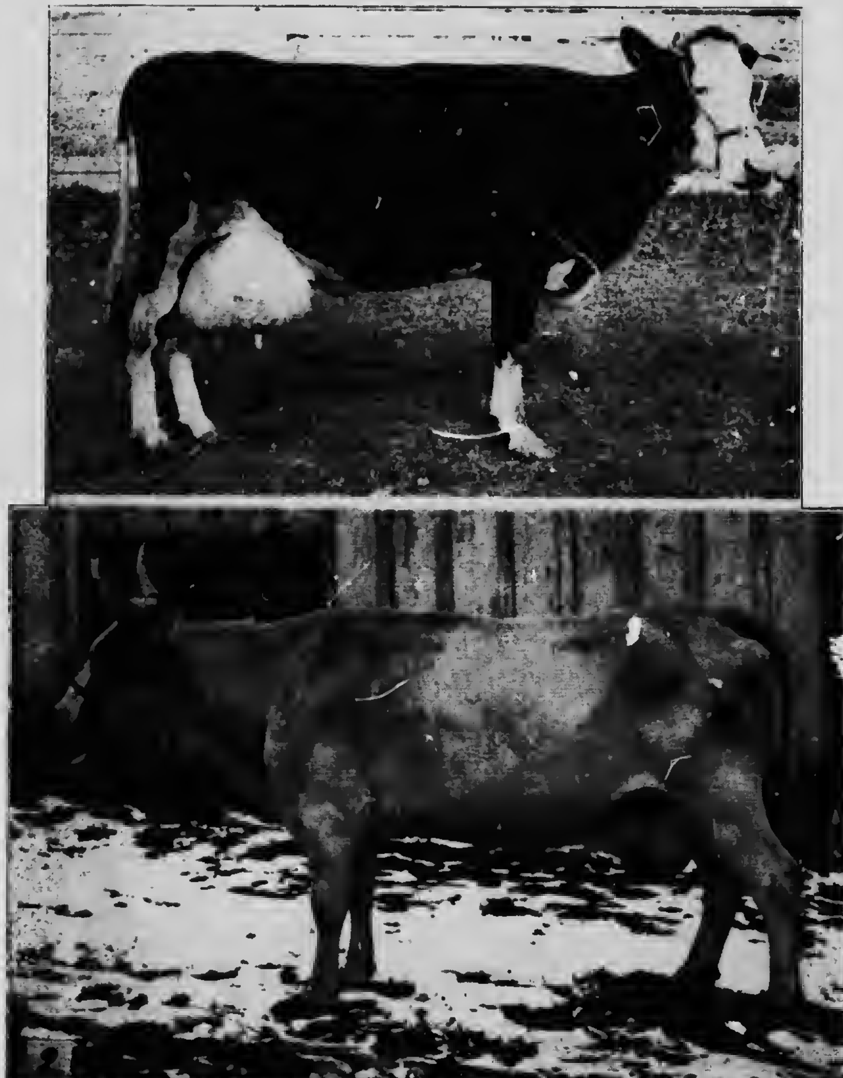
III. Bovine to Bovine.

A. In the Herd.

1. By respiration in infected stables.
2. By ingestion from contaminated mangers, feeding boxes, watering utensils, etc.
3. To calves by feeding infected milk.
4. Ante-natal—This occurs rarely.

B. From Herd to Herd.

1. By transfer of infected animals. Importations, Dispersion Sales.
2. To calves by feeding unpasteurized skim-milk or whey from creameries or cheese-factories.

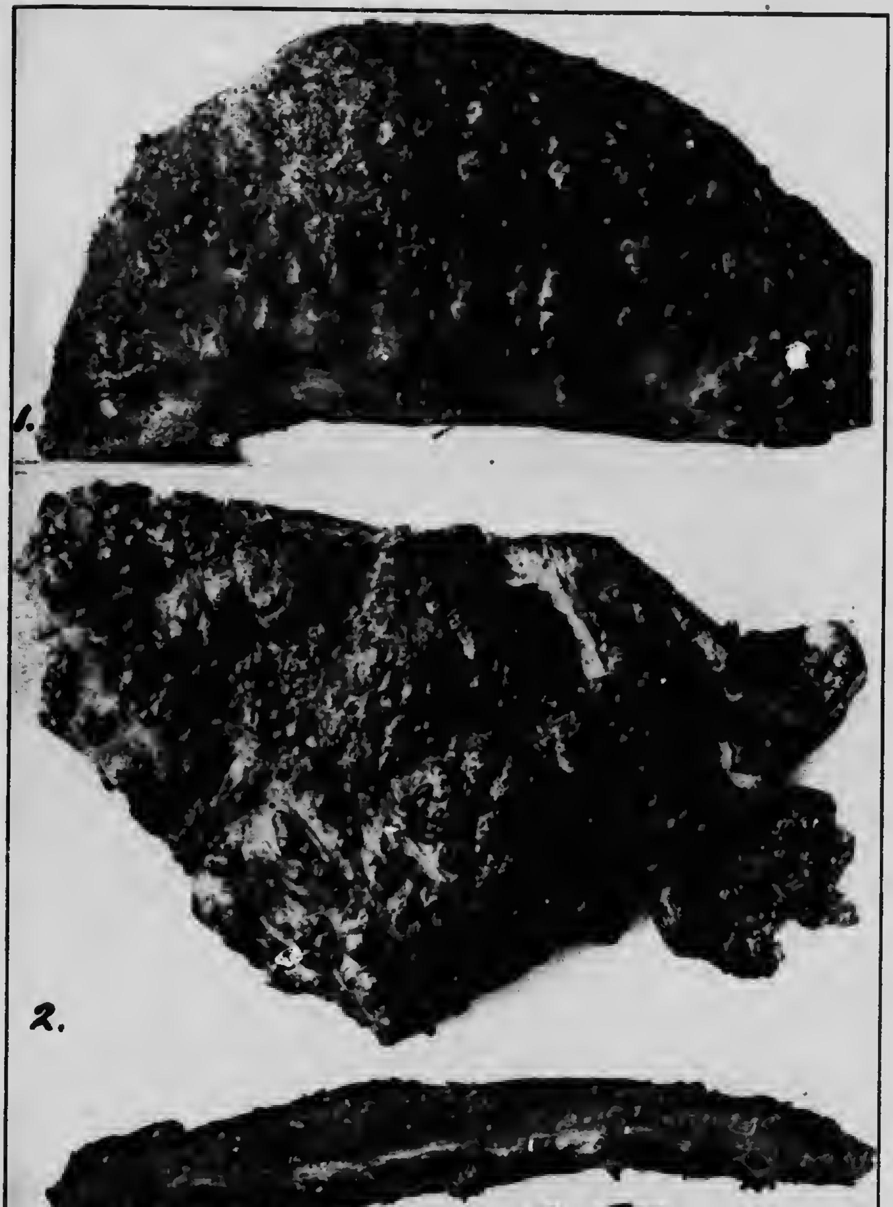


Tubercular Cattle. (photo by Edwards.)

1. Holstein, reacted to test. Post mortem examination showed intestines and udder badly tubercular.
2. Ayrshire in advanced stages of tuberculosis, very thin, skin hard. Post mortem examination showed generalized tuberculosis.

Tubercular Cows. (Photo by Edwards.)

1. Ayrshire cow, did not show noticeable external symptoms of tuberculosis, but reacted to the tuberculin test 5 degrees, and was found after slaughter to have tuberculosis fairly well advanced; lungs badly affected.
2. Grade Shorthorn showed no external symptoms of tuberculosis, reacted to tuberculin test 1 degree. Post mortem examination showed tuberculosis of the lungs, intestines and mediastinal glands.



Tubercular Specimens taken from a Holstein Cow suffering from generalized tuberculosis in an advanced degree. (photo by Edwards.)

1. Portion of the liver covered with tubercles.
2. Portion of the diaphragm covered with tubercles.
3. Sections of stomach wall showing a thick layer of tubercles completely covering the outside of the stomach.

IV. Bovine to Hogs:

1. Feeding infected milk direct from tubercular cows.
2. Feeding unpasteurized factory by-products, skim-milk or whey. Dairymen and packers state that tuberculosis is much more prevalent among hogs in dairy districts than in beef districts.
3. "Following" of cattle by hogs.
4. Feeding offal from abbatoirs.

MANAGEMENT AND ERADICATION IN CATTLE.

Detection of the Disease:

1. By Clinical Symptoms—Not to be depended upon. Cattle may be badly diseased and still appear in good condition.
2. By Post-Mortem Appearance—Detection by this method comes too late. The presence of tuberculosis in the herd should be recognized before it has made such inroads as to cause the death of even one animal. Post-mortem examination should, however, always be made to determine the seriousness of the infection.
3. By the Tuberculin Test—The subcutaneous injection of tuberculin (a product of the growth of Bacterium tuberculosis), causes a rise in temperature in tubercular animals, but has no effect in healthy animals. Tuberculin contains no living germs of tuberculosis, hence cannot cause a case of the disease. The tuberculin test is accurate and reliable. The data from 400,000 tests showed it was accurate in 98.8 per cent. of cases.

TUBERCULIN TEST CHART.

Temperature before injection.			Temperature after injection. Injection at 10 p.m.						Before and after injec. Maximum.	
4 p.m.	6 p.m.	9 p.m.	6 a.m.	8 a.m.	10 a.m.	12 n.	2 p.m.	4 p.m.	Before.	After.
100.2	101.2	101.8	100.1	100.4	100.4	100.3	100.6	100.8	101.8	100.8
101.1	101.0	101.1	100.8	103.5	104.0	104.0	103.6	102.8	101.1	*104.0
101.9	101.7	102.1	102.5	104.5	106.1	106.3	104.4	102.1	102.1	*106.3
102.3	101.9	102.6	103.4	104.9	105.9	105.5	103.2	102.8	102.6	*105.9

*Tubercular.

ERADICATION.

Essential Points:

1. Detection of diseased animals by applying the tuberculin test.
2. Separation of the healthy from the tubercular stock, and prevention of carrying infection on clothing, shoes or in any other ways.
3. Feeding of calves with milk from healthy cows only, or own dam's milk after pasteurization at 185° F. for a minute. Keeping calves entirely separated from the tubercular stock.
4. Cows in advanced stages are best slaughtered. Valuable animals reacting to the test may be kept for breeding purposes. Others may be fattened and sold for meat if slaughtered under competent inspection.

Prevention:

1. Keep tuberculosis out of the herd by buying new animals subject to the tuberculin test; or by keeping newly-purchased animals in quarantine for three months and testing them before they are placed in the herd.
2. Do not feed unpasteurized factory by-products, as skim-milk or whey, to calves or hogs.
3. Test the healthy herd at least once a year (twice is better) to detect cases possibly creeping in.

Tuberculin for testing cattle is supplied free of charge by the Dominion Department of Agriculture. A veterinary surgeon must be employed to make the test and through him the tuberculin is obtained.

Tuberculosis of Poultry.

SYMPTOMS OF THE DISEASE

(A) *Antemortem Symptoms.*

In live fowl it is difficult to detect the diseases in its early stages. As the disease advances, however, the following symptoms are liable to develop:

1. Emaciation.—Notwithstanding the fact that the affected bird's appetite keeps good, and it continues to eat as much or more than the healthy fowl, it will frequently get thin, until eventually it becomes little more than skin and bone. The breast and legs lose all their flesh, and on picking up the bird it will be found to be very light in weight.

This symptom, however, does not always occur: some birds even in advanced stages of the disease will remain fat. Such birds will be very mopy and inactive.

2. Paleness.—The unfeathered parts of the head, around the eyes and mouth, the comb and wattles, become pale and dull and though the eyes usually remain bright and clear, they lack life and fire and are often closed. The feathers become dry and lack lustre of health.

3. Listlessness.—Affected birds gradually lose their vigor and become listless and inactive, being inclined to mope around and lie down when not feeding.

4. Lameness.—When tubercles develop in the bones and joints, lameness occurs.

5. Egg Laying is frequently reduced to a minimum.

(B) *Postmortem Symptoms.*

Though it may be difficult to determine with certainty whether or not the disease is present in the live bird, it is comparatively easy to determine the presence of the disease in birds suffering from it which have died, or have been killed for examination.

The presence of tubercles in the liver, spleen, intestines or other parts, is indicative of the disease. But as there are other diseases which may cause conditions in the liver, lungs and intestines closely simulating tuberculosis, it is usually

1.

2.

3.

1. Adult hen in advanced stages of tuberculosis, showing extreme emaciation due to the disease. The owner of the bird who sent it for examination stated that it had continued to eat heartily, but had not been laying for some time. The crop was full of grain. Other members of the flock were affected with the disease in all stages, and many died during the previous eighteen months. (Original.)
2. Liver, spleen and intestines of hen badly affected with tuberculosis, showing many small, as well as large, tubercles. (Original.)
3. Tubercular lungs and bones from a hen. (Original.)

necessary, if we are to be certain whether tuberculosis is present or not, to make a bacteriological examination of the affected parts. is examination can be made only by the bacteriologist who has the necessary apparatus. We are prepared at the Bacteriological Laboratory of the Ontario Agricultural College to examine, free of charge, and report upon any suspected cases which are sent in for examination.

TUBERCLES IN THE LIVER.—The liver is the most commonly affected organ in cases of fowl tuberculosis. The tubercles are readily seen as pale yellow spots or lumps, varying in size, scattered over the surface, and sometimes projecting from the surface, and when the liver is cut open they will be found present throughout the whole mass of the liver tissue.

The tubercular liver is usually softer and more easily torn than the healthy liver, and the tubercles, as little lumps, are easily broken away from the surrounding tissue.

Sometimes an enlargement of the liver accompanies the disease. We have found tubercular livers that were five or six times larger than normal. Such livers were one dense mass of tubercles. In such a case, practically the whole liver tissue was dead, and the enlargement was due to an attempt of the liver to get the better of the disease.

TUBERCLES IN THE SPLEEN.—The spleen is the little purplish red organ situated just under the liver. When the liver is tubercular, the spleen is usually also affected. As in the liver, the tubercles can be easily seen as white or pale yellow lumps varying in size and usually sticking out from the surface, thus making the spleen irregular in shape and frequently enlarged.

TUBERCLES IN THE INTESTINES.—The intestines are the next most commonly affected organ in cases of fowl tuberculosis. Here the tubercles are found within or on the intestinal walls as hard lumps ranging in size from a pea to a chestnut. Their presence here is liable to cause considerable constriction leading to partial stoppage of the bowels. The droppings from a bird so affected are heavily infested with the tubercle bacteria, and readily spread the disease among the flock.

TUBERCLES IN THE LUNGS.—While tubercular affection of the lungs is common in human tuberculosis, it is not so frequently present in avian tuberculosis. However, the lungs of birds are sometimes affected with tuberculosis, and, as in the case of the liver and spleen, the tubercles are found in the lung tissue as little hard, pale yellow lumps which interfere with the action of the lungs, and gradually destroy the lung tissue.

Similar looking lumps are produced in the lungs of little chicks, often resulting fatally, in the disease known as Aspergillosis, which is caused by the fungus *Aspergillus fumigatus*. The spores of this fungus are occasionally present on grain and other chicken food. When these microscopic spores get into the chick's lungs they germinate, and the fungus develops, producing tubercle-like lumps, which cannot be distinguished from genuine tubercles except by microscopic examination.

TUBERCLES IN THE BONES.—Tubercles are liable to be present in any of the bones of the body of infected birds. They are most commonly found in the leg bones, particularly at the joints. They will appear as pale yellow irregular swellings of the bone. Their presence at the joints causes inflammation, soreness, softening and decay, with accompanying difficulty of movement.

TUBERCLES IN THE OVARIES.—Occasionally tubercles are found in the ovaries. In such cases there is danger of the eggs being infected with the tubercle bacteria. Chicks hatched from such eggs are liable to have the disease develop at an early date.

Dissemination of the Disease.

Tuberculosis usually enters a flock through the introduction of a bird suffering from the disease. A bird, as previously described, may be quite seriously affected without showing any marked external symptoms. Such a bird will readily spread the disease through the flock by its contaminated droppings.

The disease is widespread in Ontario. We have received for examination numerous tubercular fowl from twenty-nine different counties in the province during the last five years.

Control and Eradication of the Disease.

Care should be taken in buying new stock that birds are obtained only from flocks known to be free of the disease.

When once the disease gets established in a flock it is difficult to eradicate except by the most drastic measures. The quickest and most effective method is to kill off all the birds that have run with those proven to have the disease and to disinfect the entire premises as thoroughly as possible.

New stock should be obtained from healthy sources, but should not be placed on the runs which had been used by the diseased flock for a year or more. The houses, providing they have been thoroughly disinfected, may of course be used.

The first thing to do in putting the poultry premises in sanitary condition, is to scrape the roosts, walls, ceilings, floors and nest boxes of the houses thoroughly clean with a hoe or other convenient implement. Accumulated manure may be mixed with lime, spread on the land and ploughed under. Loose litter, pieces of boards or other valueless material should be completely burned. When this has been done, the entire inside of the house may be washed down with some good disinfectant such as carbolic acid, one part in twenty of water, zenoleum, lysol, chloronaphtholeum, or other disinfectants, in the strengths indicated by the manufacturers. Any of these may be put on with a spray pump. In place of these, quicklime in the form of whitewash may be used, prepared as follows: Slake the quicklime by adding water in the proportion of one and one-half pints of water to each quart of lime, or by weight, sixty parts of water to one hundred parts of lime. The resulting dry powder is hydrate of lime. For use mix one quart of this with four quarts of water. This must be freshly prepared in small lots and used immediately. It is best applied by means of a spray pump, although it may be put on with a brush or broom. If a spray pump is used, the slaked lime should be put through a fine sieve or strainer in order to prevent clogging of the nozzle. It is important that every crack and crevice and every particle of surface be covered with the disinfectant. After disinfection, clean boards may be placed beneath the roosts to catch the droppings, thus facilitating the work of future cleaning. Slaked lime placed on these boards will absorb the moisture from the droppings besides adding to their fertilizing value. Disinfection of the houses should be carried out at intervals as long as any diseased birds remain in the flock.

To disinfect the runs is a difficult matter, because it is impossible to have the disinfectant come into contact with each minute particle of soil. The best that can be done is to completely cover the ground with freshly-slaked lime and plough under. Sow some quick-growing crop for green manure, lime and plough under again. By this method the soil can eventually be well disinfected. The fact must be kept in mind, however, that any tubercular fowls may be continually reinfecting the soil by voiding the tubercle bacilli with their droppings; consequently, it would be impossible to keep the soil free from infection so long as diseased fowls were kept on that ground.

Detailed information on Tuberculosis is contained in the "Report of the International Commission on the Control of Bovine Tuberculosis." Address the Veterinary Director-General, Department of Agriculture, Ottawa.

Diphtheria.

Diphtheria is a highly fatal infectious human disease, common in many countries. It is caused by *Bacillus diphtheriae* also known as the *Kloebs-Loeffler bacillus*, from the names of the men who first identified it as the cause. The disease is usually an affection of the throat, where the bacillus finds lodgement either through the mouth or nose. As the bacillus multiplies on the mucous lining of the throat, it produces a very strong toxin or poison that is absorbed into the system. In addition to this toxin, a false membrane is produced in the throat consisting of fibrinous exudate, bacilli and dead cellular tissue, the presence of which causes partial suffocation. The toxin, however, is the worst feature of the disease, and it is this which is responsible for the high mortality.

The bacillus is given off in large numbers during expectoration, coughing, sneezing and talking of patients suffering from the disease. Hence the necessity of strict isolation of all diphtheria cases.

To combat the effect of the toxin, subcutaneous injections of diphtheria antitoxic serum are made. These injections should be made as soon as possible after the disease is determined, or even suspected, by a medical man. This antitoxic serum neutralizes the toxin produced in the body by the diphtheria bacilli, providing too large a quantity has not been produced before the injection.

Diphtheria Carriers.—Patients who recover from the disease will sometimes have the bacilli present in their throat, mouth and nose for weeks or months unless every care is given to thoroughly disinfect these parts. Such individuals are known as diphtheria carriers, and are a source of danger to the community in which they mix, as they are liable to spread the disease. Some people are immune to the disease and will not contract it though exposed to infection. These people may have the diphtheria bacillus present in their nose, mouth and throat without suspecting it, and so spread the disease to others who are not immune. These also are known as diphtheria carriers and are more dangerous than recovered patients, as they are not suspected of having the bacilli.

As the diphtheria bacillus will grow and multiply in milk, the disease is readily spread through this medium should it get contaminated with the diphtheria bacillus. Hence the greatest care should be taken that diphtheria carriers, *i.e.*, persons suffering from or recently recovered from diphtheria, or persons coming in contact with cases of diphtheria, should not have anything to do with the handling of milk or other foods.

Small-pox.

The micro-organism responsible for small-pox has never yet been satisfactorily demonstrated. As the virus can pass through the pores of a porcelain filter, it is considered as a filterable or ultramicroscopic virus, the organism being too small to be observed even with the highest magnifying microscope.

Formerly this disease was much more prevalent than it is to-day. The decrease in its occurrence is due to the general practise of small-pox vaccination. The vaccine used in this connection is a mild form of the virus (cow-pox) which is produced with the greatest care to prevent any contamination or injurious effect following its use. Formerly, when sufficient care was not practised in the preparation of the vaccine, there were occasional bad results following its use, due to contamination of the vaccine with other disease-producing micro-organisms.

It is generally known that a person who has had small-pox once and recovered will not, as a rule, take the disease again. Vaccination has the same effect in this particular as an attack of the disease. As the disease is very contagious, the strictest isolation of patients is necessary to prevent the disease spreading.

Epidemic Cerebro-Spinal Meningitis.

Meningitis, that is inflammation of the meninges or membrane that covers the brain and spinal cord, may be induced by a variety of different micro-organisms, such as the pneumococcus, influenza bacillus and the tubercle bacillus, but the so-called *epidemic-cerebro spinal meningitis* is caused by one species of bacteria known as the *Meningococcus* or *Micrococcus meningitidis.*

The meningococcus gains entrance to the body usually at the nose or mouth and from thence gets established at the base of the brain and in the cord where it causes a violent inflammation, frequently fatal. Children and young adults are most frequently affected. Above the age of thirty-five few cases occur.

The meningococcus quickly dies on drying out and so it is considered that the disease is spread mostly by direct contact with individuals suffering from the disease, or carriers, and from particles of sputum, nasal discharges, handkerchiefs, etc., contaminated by such. Hence the necessity for the isolation of sufferers from this disease and careful disinfecting of nasal and mouth discharges and articles contaminated by such.

An antimenigococcal serum is used curatively. This is injected directly into the spinal canal by lumbar puncture.

Influenza.

The disease known as influenza can be traced back to the fifteenth century. At times a few cases occur here and there, but occasionally a great epidemic will spread over the entire civilized world. The last great epidemic reached Russia from the East in the fall of 1889, and gradually spread over Europe and to America, causing much suffering and many deaths. Since then we have had more or less of it, especially during the winter months.

Bacillus influenzae is one of the smallest bacilli that cause disease, except the ultramicroscopic viruses. It enters the body through mouth and nose, develops on the mucous surfaces, thence finding its way to the lungs where it is liable to cause a form of pneumonia. The bacilli will not grow readily outside the human body. The bacilli are present in large numbers in the secretions of the throat, nose and mouth of patients, and it is through these secretions that the disease is spread from person to person.

No serum or vaccine treatment has so far been successful in combating the disease.

Epidemic Infantile Paralysis.

This is an infectious disease affecting mostly young children, 1-2 years old, but older children and even adults are occasionally affected. The chief symptoms of the disease are fever with or without a sore throat, followed in a few days by paralysis. There is usually permanent injury to parts of the nervous system resulting in deformity of the body.

Until recently very little was known regarding the specific cause of the disease. Within the last five years, however, researches conducted during outbreaks in the United States have added to our knowledge of the cause and methods by which the disease is spread.

The micro-organism which causes the disease is very minute, being one of the filterable viruses, but in one stage at least of its life history it can be rendered visible with the high-power microscope.

It is considered that the micro-organism gains entrance to the body through the nose and throat, finally locating in the nervous system, particularly in the brain and spinal cord. The micro-organism is not readily killed by drying, and so it is considered that the disease is spread by inhalation of contaminated dust as well as by fresh material from nose and throat of the patients.

Typhus Fever.

Typhus fever is a highly contagious disease, formely known as "jail fever," "camp fever," and "hospital fever." It used to be common where people were being crowded together in unclean conditions. It has recently been conclusively demonstrated that the disease is most commonly spread by the body louse and head louse. Thanks to modern hygienic conditions, the disease has been practically banished from civilized communities.

The typhus fever bacillus is a small anærobic bacillus, *i.e.*, it will not grow in the presence of air. When it gains entrance to the body through the sucking tube of an infected louse, it multiplies in the blood and produces a high fever and characteristic rash with a high mortality. During the epidemic which raged in Serbia in 1915, it is estimated that 135,000 persons perished of the infection.

Mumps.

Mumps is a contagious disease, the exact cause of which has not yet been satisfactorily determined. A diplococcus has been isolated from the glands of affected individuals in a number of cases, the inoculation of which into the glandular system of a dog resulted in swelling of the parotid gland and fever.

The disease does not produce high mortality. It is an affection of the glandular system which causes enlargements of the glands accompanied by fever and a general low condition. Isolation of patients should be insisted upon.

Scarlet Fever.

Scarlet fever is an acute highly infectious disease, the specific cause of which is not yet known. It produces a high fever, with skin eruption and desquamation and gangrenous inflammation of the throat, with a fairly high mortality.

It is readily spread by contaminated milk, a number of epidemics having been traced to such a source. Consequently, patients or those having the care of patients should not have anything to do with the handling of milk for the public supply. Strict isolation of patients until complete recovery should be insisted upon. followed by thorough disinfection of the isolation chamber.

Measles.

Measles is a highly contagious disease. producing fever and skin desquamation with other complications. The cause is a filterable virus or micro-organism too small to be visible with the high-power microscope. The virus is present in the blood and in the secretions of nose, mouth and throat of patients. Children are more commonly affected than adults. The mortality from this disease is not high, but it frequently causes complications and opens the way for other diseases.

Gonorrhœa.

Gonorrhœa is a contagious venereal disease widely disseminated, caused by *Microroccus gonorrhœa.* A purulent inflammation is established at point of infection which becomes chronic. The disease slowly spreads to other parts of the body, particularly to the joints where it affects the synovial membranes, causing gonorrheal rheumatism, and to the valves of the heart where it causes endocarditis. It is estimated that 10 per cent. of all cases of blindness are due to this disease, and that in the United States there are at least 12,000 children blind from this cause, through gonorrhœal ophthalmia following infection of the eyes at birth. The disease is spread mostly by sexual intercourse, but also through careless use of towels, wash-cloths and bath tubs, particularly in institutions and public baths.

Syphilis.

Syphilis is a dread contagious and hereditary venereal disease, caused by a spiral-shaped micro-organism known as *Treponema-pallidum.* On gaining entrance to the body tissue this micro-organism begins to multiply and to produce a toxin, which, acting locally, produces a chancre. This is the first stage of the disease. In a few weeks after the production of the chancre at the point of infection, the whole system becomes invaded with the virus, leading to grave and general constitutional disturbances very complex in character. Every tissue in the body is liable to be affected with tumor formation, ulcers, granulation, wasting away and death.

Syphilis is one of the very few diseases that are congenital. It is handed down from parent, either father or mother, to the child with dire results, and as a consequence there is more human misery from this disease than from any other.

Asiatic Cholera.

The home of Asiatic cholera, as the name implies, is in Asiatic countries, particularly India. Here in certain districts it is more or less always present, and from thence it is liable to spread by the trade routes, both land and sea, to other countries, thus causing epidemics of cholera wherever it gets established. During the nineteenth century several widespread epidemics occurred in Europe and America, causing many fatalities. During an outbreak in Germany in 1892, there were 17,000 cases with 8,600 deaths all in a few weeks.

The disease is caused by the cholera spirillum or *Cholera Vibrio,* a small spiral bacterium which enters the system through the mouth with contaminated food or water and becomes established in the intestines, where it multiplies and thus induces the disease. It causes acute diarrhœa, vomiting, great exhaustion, acute thirst, weakness of the heart, cramps and other symptoms, leading to death. The causal organism is passed out in great numbers in the dejecta of the patients, this being the main cause of the disease spreading through a community. The spirilla live in water or contaminated food for a long time, and thus may be transferred long distances.

Owing to the strict quarantine regulations that have been established at the ports of landing in most civilized countries, the disease is now prevented from spreading, as was formerly common.

BUBONIC PLAGUE.

Bubonic plague is another acute infectious disease common in Eastern countries, which runs a rapid, severe course, often ending fatally. It is characterized by high fever, hemorrhages, pustules or Buboes, extreme weakness and exhaustion.

It is caused by a small bacillus known as *Bacillus pestis* or the *Plague bacillus.* This bacillus gains entrance to the body mostly through the skin by wounds, scratches, insect bites, etc. On gaining entrance to the body it multiplies and spreads to other parts by means of the lymph and circulatory systems. Rats, fleas, flies, bugs and lice are all active agents of dissemination in connection with this disease.

Strict quarantine regulations at ports of entry are largely responsible for preventing this disease from entering other countries than those where it is common.

LEPROSY.

Leprosy is a dread contagious disease endemic in India, Japan and other Asiatic c[illegible] A limited number of cases occur on the North American continent an[illegible] European countries. Its cause is *Bacillus leprae,* an organism very like [illegible] *tuberculosis* in many ways. The bacillus is not known to develop naturally outside the human body. The disease is most commonly spread from individual to individual by direct contact of person or clothes. An interesting case was recently reported from New York, where a young lady developed the disease on head and face through wearing a coil of false hair. This hair was traced to a shipment that arrived from the East, some specimens of which had been obtained from a district in which leprosy was common.

The bacillus, when growing in the body tissue, produces a poison which causes a rot to develop, giving terrible distortion and mutilation, finally ending in death.

Persons suffering from the disease are segregated. No cure for the disease is known at present.

ANTHRAX.

Anthrax is a highly contagious, usually fatal disease, affecting primarily herbivorous animals as cattle, sheep, horses and goats, but also affecting man, swine, cats and dogs. The two latter, however, are only slightly susceptible.

The disease is one of the oldest known. Many references to it are found in ancient writings. It exists in all countries and latitudes, being most prevalent in Europe, China, Siberia, South Africa and South America, where it causes heavy losses to live stock owners.

The cause of the disease is *Bacillus anthracis,* a comparatively large, rod-shaped micro-organism, which gains entrance to the body either through wounds or by ingestion with contaminated food or water, or by inhalation from the air. With cattle, sheep and horses, ingestion with food and water is the more common means whereby the disease becomes established.

On gaining entrance to the body the bacillus rapidly multiplies and spreads throughout the system by means of the blood. In one or two days every blood vessel in the body will be crowded with the bacilli. As a result of this the animal appears to be suddenly seized with trembling and swaying motions, has a haggard expression, colicy pains, difficult breathing, dark bloody discharges from nose and rectum, followed by convulsions and death. Death occurs in from one to five days after symptoms are first noticed; sheep, one day; cattle, two to five days; horses, one to five days. The blood will not coagulate like ordinary blood, but is thick, dark and tarlike, and every drop of it in the animal's body will contain many of the bacilli; consequently the bloody discharges are highly infectious and should be carefully disinfected or burned. After death the bacilli will still be present in the blood in immense numbers; consequently the carcase should *not be skinned or cut open,* or the bacilli will be scattered around.

When anthrax is suspected, a veterinary surgeon should be called in and he should send a bit of the ear or a smear of blood on a piece of paper, carefully wrapped up and enclosed in a bottle or box, to the Veterinary Director-General at Ottawa, who will have an analysis of the blood made to determine whether or not anthrax is present. The carcase should be either burned or buried deeply in quicklime and a thorough disinfection of the premises carried out.

The *anthrax bacilli* are very resistant spore formers, but the spores are produced only in the presence of air. This is another reason why the carcase should not be skinned or cut up, as the millions of the bacilli in the blood of the body will be destroyed by the ordinary process of putrefaction after the carcase is buried, if they are not allowed to get to the air. If they get exposed to the air they will produce spores and it is mainly by these spores that the disease is spread. The spores will remain dormant for years in the soil on pastures or on fodder, or on the surface of anything, where they are deposited, but will immediately become active on gaining entrance to the body of an animal. Pasture fields once contaminated are liable to cause the disease whenever cattle are turned into them.

Anthrax in man is known as wool sorters' disease and malignant pustule. It is contracted by people handling wool and hides that have been removed from infected animals. Such wool and hides are liable to have large numbers of the anthrax bacterial spores on them, which set up the disease on gaining entrance to the body either through wounds, breathing or ingestion.

Contaminated drainage water from tanneries, after entering streams and flowing through pasture fields is a frequent cause of outbreaks of anthrax.

Prevention—Vaccination.—There is no cure for anthrax when once it gets established in an animal, but other members of the herd or flock may be vaccinated with anthrax vaccine to prevent their taking the disease. This vaccine is active in the body for about one year.

Anthrax vaccine may be obtained from the Veterinary Director-General at Ottawa at a cost of five cents per dose, and the outfit for administering the vaccine at a cost of fifty cents. Full directions are sent with the material.

The vaccine is administered in two treatments, the second treatment being given ten to twelve days after the first, and the animal will be immune to the disease twelve days after the second treatment.

Any case of anthrax should be reported to the Veterinary Director-General or to a Government inspector.

Symptomatic Anthrax, also known as "Black Leg" and "Quarter Evil."

This is a disease of cattle widely spread in Europe, America and Africa. It is caused by an anaerobic bacillus known as *Bacillus anthracis symptomatici* or *Bacillus chauvei,* fairly common in the soil. The bacillus enters the body through a wound, usually in one of the quarters, and the disease runs a rapid course, usually ending fatally in one or two days.

Symptoms.—Local swellings are produced around the point of entrance, usually the thigh, shoulder or neck, and may attain a large size in a few hours. The swelling is due to the production of gas in the tissues beneath the skin, and if the swelling is pressed or firmly rubbed a crackling sensation will be felt. Lancing the swelling causes a red, frothy, strong-smelling fluid to issue, which is infectious. The muscle tissue of the affected part is very dark; hence the name "Black Leg."

As the swelling increases in size, the general symptoms appear:

The temperature rises to 107° F.; respiration is rapid, 140 per minute. The animal falls down and is unable to rise; the extremities turn cold; violent convulsions ensue, followed by death.

The carcase should be burned or buried deeply in quick-lime, and the premises thoroughly disinfected.

There is no cure for the disease. Other animals in the herd should be vaccinated with black leg vaccine at once to prevent their taking the disease. The vaccine may be obtained from the Veterinary Director-General at Ottawa. It is put up in the shape of pills, which are injected under the skin of the shoulder with a hypodermic syringe. The complete outfit for injecting costs 50 cents.

Contagious Abortion of Cattle.

Contagious abortion of cattle is a disease which is considered to cause heavier financial losses among cattle than any other disease, except, possibly, tuberculosis. It is very common in Europe and on the American Continent. Much investigational work has been done and is still being carried on in connection with this disease. The cause of the disease is known, but satisfactory measures for its complete control or eradication have not yet ben devised.

The trouble is due to the action of *Bacillus abortus* in the foetus and uterus of pregnant cows, setting up a local inflammation, which leads to any one or all of the following conditions—abortion, premature birth, retention of the foetal membranes, metritis and sterility.

Abortion may take place a[illegible] time during pregnancy. If it occurs in the early stages of gestation, the sm[illegible] bryo comes away enveloped in the inconspicuous foetal membranes and easi[illegible] escapes detection. If it occurs after the foetus has attained considerable size, the foetal membranes are usually retained by the cow and the assistance of the veterinary surgeon is required to remove them. They should be removed within twelve hours after abortion, or fatal consequences may result from blood poisoning or bacterial infection. A catarrhal condition of the uterus may cause gradual death of the foetus which is not immediately expelled but becomes mummified.

Heifers, as a rule, abort earlier than cows. In herds recently infected the animals usually abort in from three to five months after pregnancy; in herds where the disease is of long standing abortion frequently takes place from the fifth to the seventh month of pregnancy.

Unfortunately, there are no well-marked symptoms of the disease until abortion is about to take place. The animal generally will appear to be normal and in good health until just before aborting. Then may be noticed a springing of the udder, enlargement of the vulva, an odorless discharge from the vagina, dullness and desire to be alone. Any, or all, or none, of these symptoms may be noticed shortly before abortion takes place.

Much of the difficult experienced in the control of the disease is due to lack of knowledge as to how the bacillus gets into the uterus.

Some investigators contend that it gains entrance indirectly through the alimentary canal by the ingestion of contaminated food and water; others contend that it gains entrance mainly, if not solely, through the genital organs previous to the sealing of the uterus, which occurs within thirty days of conception.

It has recently been shown (Schroeder and Cotton, 1917) that the abortion bacillus is frequently present in the udder and adjacent lymph glands of non-pregnant cows, but not in any other part of the body, and that it is given off in the milk from such cows, the cows appearing normal and healthy in every particular. In the case of affected pregnant cows, the bacillus is found in the uterus, where it sets up the inflammation leading to abortion. It has been experimentally demonstrated that the bacillus will pass from the udder to the uterus of pregnant animals, the bacillus having an affinity for foetal tissues. Consequently, the disease may be spread by milking operations, the milker passing from a non-pregnant animal that has the bacillus in the udder and is giving it off in the milk, to a pregnant animal, thus conveying the bacillus on the hands to the teats of the pregnant animal, whence it would gain entrance to the udder and pass to the uterus, leading to abortion.

Attempts are being made to prepare a serum or vaccine the injection of which into breeding cows will prevent abortion. Some success has been reported, but further investigational experiments are necessary before any general application of such measures can be made.

In the meantime it is well to practise the strictest hygiene in the handling of herds where abortion is present.

The foetus, foetal membranes and exudate, which will contain the bacilli in large numbers, should be buried deeply in quicklime. Everything with which they come in contact should be thoroughly disinfected. The aborting animal should be isolated, and, so long as there is a discharge from the vulva, the external genitals, thighs and udder should be washed daily with a suitable disinfectant, as two per cent. lysol or cresol. The cow should not be bred again until all discharge has ceased. The bedding contaminated with the discharge should be burned, and the stall well disinfected after the animal is removed. The attendant in charge of animals that have aborted should not have anything to do with other cattle without first changing his clothes and disinfecting his hands.

Contagious Abortion of Mares.

So-called sporadic abortion of mares may take place following an injury such as a kick or a bad fall, or as a result of ergotism. Such cases, however, have nothing to do with contagious abortion and do not spread from animal to animal.

Contagious abortion of mares is due to a specific bacillus, *Bacillus abortivus equinus,* which like *Bacillus abortus* of cattle, gets established in the uterus, foetal membranes and foetus, setting up local inflammation, leading to expulsion of the foetus, dead or alive, at any time during pregnancy.

The symptoms of approaching abortion are not usually in evidence until just before abortion takes place. Then the animal is seized with colicy pains, restlessness, straining and a swollen vulva, with a mucous discharge, is noticeable. After abortion, the symptoms are more specific. There is a chocolate brown fluid discharge from vulva, which has a typical offensive odor, and the foetal membranes are inclined to remain intact, thus necessitating artificial removal to prevent blood poisoning.

The mortality of aborting mares is not high, but the animal after abortion is liable to become unthrifty and the foetus or colt, if born alive, has a strong tendency to septic arthritis or joint ill. Hence the disease is the cause of considerable financial loss to the farmer who has to contend with it.

The disease has been known in Europe for many years, but it was not found on the American Continent until 1886, when it appeared in the Mississippi Valley.

Since then it has spread far and wide in the United States and Canada. Although many investigations were made both in Europe and America, it was not until 1912 that the cause of the disease was discovered. In that year, E. S. Good, of Kentucky, discovered the bacillus which causes the disease. The same year Dr. Schofield, of Toronto, discovered the same bacillus in some cases of joint ill in colts, which had developed in districts in Ontario where contagious abortion of mares was prevalent, and the following year found the same bacillus in cases of contagious abortion of mares in Ontario.

Method of Spreading.—The disease is spread mainly by the discharges from the vulva of aborting animals. If a mare that has aborted is served before all discharges from the vulva have ceased and the gentalia have been efficiently disinfected, then the stallion is liable to get contaminated with the bacillus and spread the disease to other mares which he subsequently serves. If the discharges from an aborting mare are allowed to contaminate the bedding or other materials that other mares come in contact with, then these mares are liable to contract the disease. If the discharges are allowed to contaminate water or food materials that are given to other mares, the latter are liable to contract the disease.

Measures for Control.—(As suggested by Dr. Schofield, recently of Toronto.)

1. Three months must elapse between abortion and subsequent breeding.
2. Mares that have aborted must not be bred if there is evidence of uterine catarrh, even after three months.
3. Mares that have aborted must only be bred at the end of the stallion season.
4. Application of an efficient disinfectant to the external genitalia of the stallion after each service in affected districts.

These regulations should also extend to mares in affected districts whose colts have developed septic arthritis.

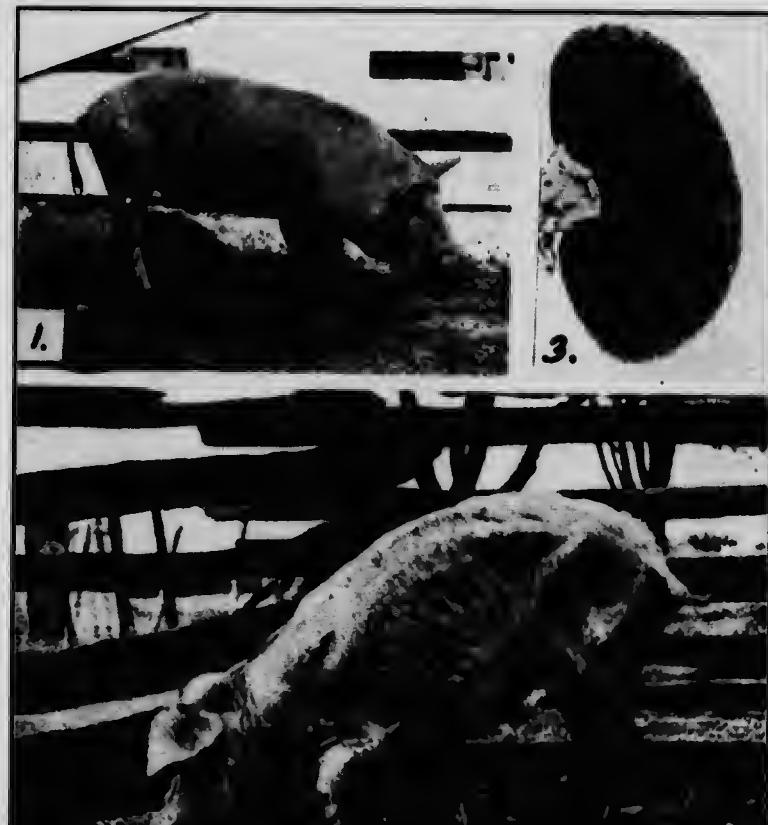
Measures to be Employed at Time of, or Subsequent To, Abortion.

1. Isolation of mare at first sign of approaching abortion.
2. After abortion the foetus and membranes should be burned, if possible, or buried deeply in quicklime.
3. Those handling the foetus and mare should disinfect hands and clothing.
4. Bedding should be burned and the stall washed with a strong disinfectant.
5. External genitals, thighs and tail of mare should be washed daily with a good disinfectant. Two per cent. bacterol, lysol, or creosol, is satisfactory for this purpose.
6. Isolation of mare should be maintained for at least a month or until all evidence of uterine discharge has ceased.

Treating the animal with drugs, as carbolic acid, black haw and methylene blue, though popular in some districts, cannot be recommended as being of any value.

Hog Cholera.

Hog cholera is a highly contagious disease of swine. So far as known, it does not affect other animals or man. It is caused by a filterable virus or ultra-microscopic organism, i.e., an organism so small as to pass through the finest porcelain filters and too small to be visible even with the highest-power microscope. A bacillus known as *Bacillus cholera suis,* which is frequently found in connection with hog cholera and is about the size of typhoid bacillus, was formerly thought to be the cause of the disease. It is now known to be merely an occasional accompaniment of the disease and not its cause.



Hog Cholera.

1. Hog suffering from the acute type of hog cholera. (After Lynch.)
2. Hog suffering from the chronic type of hog cholera—advanced stage. (After Torrance.)
3. Kidney from a hog dead of chronic hog cholera. Note the typical spotted condition.
4. Ulcerated intestine from hog dead of chronic hog cholera.

Hog cholera is considered the most serious disease of hogs and is found at present in most countries where hog raising is practised. It is very prevalent in the United States, where the average annual loss from the disease for the last forty years is estimated to be $30,000,000. The losses, however, are gradually being reduced by the use of hog cholera serum. In Canada the disease cannot be considered prevalent, although isolated outbreaks occur from time to time, following the introduction ot the virus in various ways, as by contaminated foods, garbage, cattle cars, exhibition grounds, and the handling of diseased stock.

Symptoms of Hog Cholera.—The symptoms of hog cholera differ somewhat according to the virulence of the virus and the resisting power of the hogs in any particular outbreak. Owing to this variation, two forms of the disease are recognized—the so-called acute form and the chronic form.

In the acute or severe form, the hogs sicken and die quickly, appearing to be well one day and frequently dead the next. In the chronic or less severe form, the hogs may be sick for weeks or months before they die or get better.

When cholera enters a herd, the hogs do not all become sick at once. One or two will fail to come for their feed and will be found lying down in some dark corner. On being raised up their backs will be arched, and they will shiver as with cold. They soon become thin and tucked up in the flank and stagger around when trying to walk, the hind legs being particularly weak. The eyes become inflamed and show a whitish discharge, sometimes causing the lids to stick together. When the lungs get affected there is a cough. Constipation is noticed at first, followed by diarrhoea; red and purple blotches appear on the skin of ears, belly, and inner surfaces of the legs. The temperature of the sick hogs will rise to as high as 107° F. or even higher, the normal temperature of healthy animals being 101°-104° F.

The discharges from the sick animals, both urine and faeces, contain the virus in large quantities, and so other members of the herd associating with the sick ones soon contract the disease.

Post Mortem Symptoms.—An examination of the body of a hog dead from hog cholera will usually reveal any or all of the following symptoms:

1. Purple patches on the skin.
2. Blood-colored spots, varying in size from a pin point to a pin head, on surface of lungs, heart, kidneys, and on the outer surface and inner lining of intestines and stomach. These are most common in acute cases of the disease.
3. Unlceration of the inner lining of the large intestine and particularly at the junction of the large intestine with the small intestine, where the ileo-caecal valve is situated. These are most common in the chronic form of the disease.
4. Reddening of the lymphatic glands.
5. Enlargement of the spleen in acute cases.

Methods of Spreading.—So far as known, the virus of hog cholera will not propagate outside the body of the hog. As already stated, the virus is given off in large quantities in the urine and faecal discharges of sick hogs. Anything that gets contaminated with these discharges is liable to spread the disease to healthy hogs that come in contact with it. Consequently, boxes, wagons, and cars in which sick animals are shipped, are potent sources for spreading the disease. The pens and yards in which sick anmals have run get heavily contaminated, so that anyone walking over the same get their shoes or clothes contaminated, and so may carry the disease to other herds subsequently visited. Offal from slaughter yards fed to hogs has been known to he the source of the disease in a number of outbreaks. Streams running past premises where hog cholera is present have been known to spread the disease to other places. The purchase of new stock and the borrowing or lending of stock for breeding purposes has been shown to be the cause of a number of outbreaks.

Consequently, the greatest care should be taken to strictly quarantine any place where the disease gets established. After the outbreak has been stamped out the most thorough disinfection of the premises is necessary.

PREVENTION AND TREATMENT.—From what has been said above regarding the way the disease is spread, it will at once be seen that one way to keep the disease from a healthy herd is to take all steps necessary to prevent materials contaminated by sick hogs from coming in contact with the healthy herd.

IN CANADA (By order of the Veterinary Director-General).—If by any chance the disease gains entrance to a herd anywhere in Canada, the laws of the Dominion require that a veterinary inspector be notified without delay. Failure to make this notification means loss of compensation for animals slaughtered under the Act, and liability to a heavy fine.

"The veterinary inspector, upon making sure of the existence of hog cholera, will have all the hogs on the premises slaughtered immediately. Those actually diseased are then destroyed by burning them up completely, or else deeply burying them in the ground. Hogs which are not sick, but have been in contact with the diseased ones, and are in fit condition for food, may be dressed under the supervision of the inspector. If a careful examination shows them to be healthy, they are allowed to be sold as dressed pork. The inspector assesses the value of the hogs slaughtered, and, if the owner has not been guilty of any neglect or infraction of the law, and carries out the instruction of the inspector regarding the disinfection of the place, he will receive compensation for his losses up to *two-thirds of the assessed value.*

"The premises occupied by the diseased hogs are placed in quarantine until thoroughly cleaned and disinfected to the satisfaction of the inspector, and no fresh hogs are allowed on the premises for a period of at least three months afterward. The inspector then revisits the premises to make sure that the regulations have been complied with, and, if satisfied that such is the case, will recommend to the Minister of Agriculture the release of the premises from quarantine. The Minister is the only person authorized to grant this release, and he grants it on the recommendation of the inspector.

The following are the Official Rules for the cleansing and disinfecting of premises after outbreaks of hog cholera:

"After infected hogs have been slaughtered, the carcasses should either be completely burned or buried at a depth of at least eight feet; if buried, they should be covered to a depth of several inches with quicklime.

"In most cases it will be found safest and most profitable to remove and [illegible] the floors, partitions and lining of pens previously occupied by infected hogs, as also any rails, loose boards or other lumber to which such hogs have had access.

"Pens, other buildings and fences with which affected hogs have been in contact are, when possible, to be thoroughly gone over with hot steam or boiling water before being coated with fresh lime wash, each gallon of which should contain a pound of carbolic acid, creolin or other germicide of equal strength.

"The surface soil of pens and yards should be removed to a depth of at least six inches and well mixed with fresh lime, which should also be freely applied to the surface of the newly exposed soil. Ground so treated should receive over the lime a fresh coating of earth or gravel. Fields, orchards and gardens to which the diseased hogs have had access are to be ploughed as soon as possible.

"Every precaution should be taken to prevent the conveyance of infection from one place to another by means of the clothing or shoes of persons who have been attending to or otherwise dealing with diseased hogs.

Visitors should be discouraged during outbreaks of disease or until cleansing and disinfecting operations as above indicated have been completed.

"Animals, especially dogs, are frequently the means of conveying the disease, and should, wherever possible, be prevented from entering infected premises. When, owing to severe weather or other unavoidable cause, it is found impossible to cleanse and disinfect immediately pens or yards formerly occupied by diseased hogs, such pens or

yards should be closed up in such a manner as to prevent persons or animals obtaining access thereto until such cleansing and disinfection can be properly carried out.

"Owners of diseased hogs should bear in mind that inspectors cannot recommend the release from quarantine of any premises the disinfection of which has not been carried out in a satisfactory manner."

ANTI-HOG-CHOLERA SERUM.—In the United States the use of anti-hog-cholera serum is generally practised as a preventive, more particularly where hogs are exposed to the disease. In some districts it is almost impossible to raise hogs without the use of the serum, the disease being so prevalent that all hogs are exposed to it.

The use of this serum in Canada is forbidden by law except under Government supervision. The reason for this is that in order to render a hog permanently immune to hog cholera by the serum treatment, it is necessary to make use of the virus that causes the disease as well as the serum itself. Such a practice is desirable in districts where the disease is endemic, as is the case in many of the States. But in Canada, where the disease is not generally prevalent, the indiscriminate use of the serum and virus would mean the introduction of the disease in many districts that are free from it. The practice implies use of the disease to combat the disease.

The serum is prepared as follows:

A hog that has been rendered immune as a result of recovery from an attack of the disease, following either a natural or artificial inoculation, is rendered hyper-immune by the injection into his muscular tissues of large quantities of virulent blood, taken direct from another hog very sick of the disease. This virulent blood is injected in increasing doses, at intervals of a few days, until the blood of the animal has become hyper-immune, that is, excessively resistant to the disease.

Blood is then withdrawn from the animal by cutting off the end of the tail and catching the flow in a sterile vessel. When sufficient blood has been withdrawn, the wound is ligatured and the animal is fed up and again treated in the same way. The blood so obtained is allowed to coagulate and the serum is removed, its strength established, a preservative added, and then it is ready for use.

This serum when injected into hogs, 20 c.c. per 100 lbs. hog, will render them immune for a few weeks. It is useful when sending hogs to exhibitions where they are liable to be exposed, or when shipping them through an infected district. This method is known as the "Serum Alone Method."

To make a hog permanently immune, it is necessary to use the virus in conjunction with the serum. This may be done in one of two ways. One is known as the "Simultaneous or Quick Method," in which a dose of serum, 20 c.c. per 100 lbs. hog is injected in one place, and 1-10 that quantity of virulent blood taken from an animal sick of the disease is injected in another place. This treatment results in a mild attack of the disease. If the serum were not given, the virulent blood would cause fatal results, but the serum helps the animal to get the better of the virus, with active permanent immunity as the final result. Sometimes fatal results occur with this treatment when the serum is not sufficiently strong to offset the virus.

A better method than the above is the so-called "Combination Method." This is a combination of the serum alone and the simultaneous methods. First, treat with the serum alone method and ten days later with the simultaneous method. This, of course, takes longer time, and is more expensive, but is safer and more sure.

FOOT AND MOUTH DISEASE.

Foot and mouth disease is a highly infectious disease affecting domestic animals. Cattle are most susceptible: hogs, sheep and goats less so; while horses, dogs, cats and man are still less susceptible, and rabbits, guinea-pigs and birds are practically immune.

The disease is caused by a filterable or ultra-microscopic virus, and is spread by contact with a diseased animal or by contaminated water, bedding, food, pasture and attendants. Contaminated milk affects young stock.

The disease has been known in Europe for three centuries, where it has affected millions of cattle, thus causing heavy losses. Outbreaks occurred on the North American continent in 1870, 1880, 1884, 1902, 1908 and 1915. In the last outbreak, over two thousand herds of affected cattle, sheep and swine were slaughtered in order to stamp out the disease and prevent its further spread.

Symptoms.—In cattle symptoms develop in from two to seven days after exposure to infection. At first there is a slight fever, frequent pulse and loss of appetite. Then comes inflammation of mouth, lips and throat, accompanied by pain in swallowing, drooling of saliva, listlessness and emaciation. Vesicles, filled with fluid, appear on lips, gums, cheeks, udder, and on the feet, principally just above the hoof. These vesicles rupture, and the fluid which they contain is discharged and is very infectious. Ulcers develop around the feet, causing loss of hoof and injury to the joints.

The mortality directly resulting from the disease is usually not very high, but the losses in milk and beef resulting from an outbreak and the rapidity with which the disease spreads when once it gets started, are sufficient to warrant the government of most countries, including Canada and the United States, to institute radical measures for its control. Quarantine and slaughter of all affected animals, followed by thorough disinfection of premises, is carried out under government supervision.

In man the symptoms are similar to those in cattle, though often mild in form. The hands are most often affected, particularly at the finger tips; but the feet, toes and heels, and also other parts of the body, may become affected. In children there are more serious general symptoms than with adults.

Glanders and Farcy.

Glanders is a serious infectious disease naturally affecting horses, mules and donkeys. It is also communicable to man, sheep, goats and guinea pigs. Cattle are immune. *Bacillus malei* gaining entrance to the system is the cause of the disease, and it is spread mainly by contamination of food, mangers, drinking-troughs, etc.—rarely through wounds.

The disease may be *acute* or *chronic*, according to the virulence of the bacillus and the resistance of the animal.

Symptoms.—*The Acute Type* begins with a chill followed by fever, inflammatory changes of lymph glands, ulceration of membrane in nose and mouth, with muco-purulent discharge; then death in from one to four weeks.

The Chronic Type shows no marked characteristics in its early stages. The lymph glands in various parts of the body become infected and enlarge. Nodules develop in the mouth, nose and lungs, which are small at first, gradually enlarging to size of pea, when they break down and suppurate, thus forming chronic ulcers. The chronic form may change to the acute form at any time.

In man the disease is practically always fatal, following infection mainly through wounds.

Farcy or Cutaneous Glanders is the name given to the disease when present in the skin. Nodules form in the skin, usually break through to the surface and ulcerate. Lymph vessels swell and feel like a string of beads or knotted cord.

Owing to the heavy losses from the disease in horses and mules when an outbreak occurs, and to the ease and rapidity with which the disease spreads, the Government insists on the immediate slaughter of all affected animals and the testing with mallein all horses and mules that have been exposed to infection, all animals re-acting being slaughtered.

The Mallein Test for glanders is somewhat similar to the tuberculin test for tuberculosis. Mallein is a suspension of *Bacillus mallei* killed by the application of heat. When a dose of mallein is injected under the skin of an animal suffering from glanders, there is a rise in temperature after six to eight hours. This is accompanied by a swelling of considerable size at the point of injection which is hot and painful and persists for several days. In an animal not suffering from glanders there will be a slight rise in temperature following injection, but no hot painful swelling.

Other tests for the determination of glanders have been devised and used with more or less satisfaction. These are the guinea pig inoculation test, the complement fixation test, and the conglutination test.

White Diarrhœa of Chicks.

"White diarrhœa" of chicks is usually an infectious disease, and results in heavy losses among little chicks, particularly those which are incubator hatched. The heaviest losses usually occur between the ages of one and three weeks. In cases where the trouble is not due to an infection, the cause may be sought in improper incubation, improper brooding, overheating, chilling, poor ventilation and overcrowding.

The cause of infectious white diarrhœa of chicks has been shown in a number of outbreaks to be due to a bacillus named *Bacillus pullorum*, by Dr. Rettger, who first discovered it.

Symptoms.—Affected chicks appear small for their age, dull, hunched-up in the back, big-bellied, feathers roughened, pasted up behind with sticky, whitish, creamy discharge from vent, wings drooping and head drawn in. They isolate themselves from rest of flock, remain under the hover, eat with difficulty and utter shrill little chirps as if in pain, particularly when attempting to void excreta. In some cases the chicks will die suddenly after showing but few of the above symptoms; others will drag out a miserable existence for a time and show all the symptoms. A few get better, but most of them die.

On post-mortem examination, the following conditions are common: Chick usually emaciated and dirty; crop empty or partially filled with a slimy liquid or with food: lungs, apparently, normal; liver, pale with patches of red; kidney and spleen apparently normal; intestines, pale and for the greater part empty, except for a little greyish or brownish matter; cæca, partially filled with soft, greyish substance, occasionally cheesy or firm contents found.

Methods of Spreading.—It has been found that female chickens which recover from white diarrhœa frequently have *Bacillus pullorum* retained in their system, particularly in the ovarian tissue. The presence of the bacillus there induces a diseased condition of the ovaries. The egg yolks of the ovaries of a healthy hen in the laying condition are mostly spherical, bright golden yellow, covered with interlacing blood vessels; the egg yolks of the ovary of a hen affected with *Bacillus pullorum* will be more or less angular, dull brown and dirty greenish or otherwise discolored, frequently soft and flabby. The eggs from such a hen are very liable to contain *Bacillus pullorum* and the chicks from such eggs will have white diarrhœa. The chicks which have the disease on being hatched soon give off large numbers of bacilli in their droppings, and thus the chicks with which they associate contract the disease. One or two such chicks in a hatch will frequently cause an infection of a considerable percentage of their companions in the incubator or brooder. The greatest danger of infection is usually during the first 48 hours, but it may occur any time during the first week, after which there is not much danger.

Treatment.—Not much can be done for a chick that has contracted the disease. Steps should be taken at once to prevent the disease from spreading to the healthy ones. It is better to remove the healthy chicks to fresh quarters than to move those which are sick. Every incubator and brooder should be thoroughly disinfected before using, and between each hatch, with some good disinfectant as cresol soap.

A means for testing whether or not a laying pullet or hen is affected with *Bacillus pullorum* has been devised by Dr. Rettger. It is known as the *Agglutination Test.* A trained bacteriologist is necessary for preparing the material and conducting the test.

For the test it is necessary to have pure cultures of *Bacillus pullorum,* several strains being preferred to any one single strain. The bacterial growth from 24-hour old nutrient agar cultures is mixed with physiological salt solution and filtered through paper. The filtrate should be faintly cloudy with the suspended bacilli, and this constitutes the test solution.

A sample of blood, 3-5 c.c., is drawn into a small test-tube from the large vein under the wing of each bird to be tested. This is allowed to clot and placed in the refrigerator over night. The clear serum is then pipetted off and diluted with physiological salt solution (0.2 c.c. serum to 4.0 c.c. of salt sol.), thus giving a dilution of 1-20.

The diluted serum is then mixed with the test solution in varying quantities: 0.8, 0.4, 0.2 c.c of the diluted serum to 2.0 c.c. of the test solution, thus giving dilutions of the original serum of 1-50, 1-100 and 1-200.

The mixtures are shaken and placed in the incubator at 37° C. and examined later at intervals for agglutination. Two days incubation is sufficient for obtaining final results.

If the bird from which the blood is drawn is affected with *Bacillus pullorum,* the blood serum will cause the bacilli in the test solution to agglutinate, that is, clump together in little masses, leaving the solution around them clear. If the bird is not affected with *Bacillus pullorum* then no change will be noticed in the mixture after incubation.

Fowl Cholera.

Fowl cholera is a highly infectious disease of poultry. It is usually fatal. It spreads rapidly through a flock when once it gains entrance.

The cause of the disease is a bacillus named *Bacillus avisepticus,* first discovered in cases of the disease by Pasteur in France.

Symptoms.—The first symptom usually noticed is diarrhoea. The droppings occur frequently and consist largely of yellow-colored urates (which in health are white) suspended in a thin transparent liquid. In later stages of the disease the urates may become greenish. The affected bird separates itself from the flock, its feathers become roughened, wings droop, head is drawn in. Drowsiness and extreme weakness follow and death after a day or two is usually the result.

Post-mortem examination shows mouth, nose and throat filled with mucus, crop usually well filled with food, inflammation of the digestive system, kidneys and mesentery. Pin point hæmorrhages are found on surface of heart and tiny white spots on and in the liver. The blood vessels of the liver are congested. The duodenum or first fold of the intestines is highly inflamed and reddened on the inner surface. The intestinal contents may be creamy, brownish or green in color. The ureters are usually very noticeable on account of their being filled with the yellow urates. The bacilli are found in considerable numbers in the blood and organic tissues.

Methods of Spreading.—It is sometimes difficult to determine how the disease gains entrance to a flock. The introduction of new stock or the return of birds from poultry shows, or the contamination of food and water may be responsible in some cases. In others it appears almost to develop spontaneously. In such cases it is considered that healthy birds, resistant to the disease may have the bacillus in a low state of virulence in their system and that birds in their company that are not resistant to the disease get the bacilli from them. In these birds the disease develops and the bacilli become more virulent, and as these virulent bacilli are scattered around in the pens, runs, food and water an epidemic gets started.

Treatment.—There is no known satisfactory curative treatment. Birds that show marked symptoms of the disease should be killed at once, care being taken not to scatter the blood around, as the bacilli will be present in every drop of the blood. The bodies of the birds should be burned or buried deeply in quicklime and a thorough cleaning and disinfection of the premises carried out.

Chicken Pox, Canker, and Roup or Fowl Diphtheria.

Chicken pox, canker, roup or fowl diphtheria have given trouble to poultry raisers in Europe, United States and Canada for many years. Much work has been done on the disease, or diseases, by various pathologists on both continents. Some authorities contend that one disease only is responsible for the various conditions represented in chicken pox, canker, roup or fowl diphtheria, others again contend that the conditions referred to are separate and distinct diseases.

A local inflammation which has a tendency to spread is responsible for each condition. In chicken pox the inflammation occurs within the epithelium or skin of the comb, wattles and other parts of the head, and an exudate forming scabs is given off. With canker and roup or fowl diphtheria the inflammation occurs in the mucous membrane, or lining of the throat, nose and eye sockets and a tough, cream-colored fibrinous exudate containing pus cells and various bacteria is produced in the inflamed area.

When this exudate is produced in the larynx it frequently causes death from suffocation. When it occurs in the mouth, cankers are produced both large and small, and when it occurs in the nose and eyes, swellings develop due to the presence of large quantities of the exudate within the cavities.

Some investigators have contended that fowl diphtheria and human diphtheria are one disease due to the same species of bacteria. This theory, however, has been disproven, as the human diphtheria bacillus has not been found present in the fowl disease.

Various species of bacteria are found associated with the disease, but so far no one species of those which have been isolated has been shown to be the cause.

Some contend that the cause is an ultra-microscopic organism, and that the bacteria found present are simply associated with it. Others again contend that the disease is due to the presence of various species of bacteria, the combined associative action of which sets up the inflammation. All agree, however, that the disease is infectious and contagious and hence is due to some living virus, the exact nature of which has not so far been ascertained.

During the investigation of an extensive outbreak of pox and roup in a large flock of poultry in 1916, the writer isolated five different species of bacteria from the lesions of the birds but none of these species of bacteria produced the disease, either singly or collectively, when inoculated in various ways or fed to healthy birds. The results of the investigation thus favoring the theory that the cause of the disease is an ultra-microscopic organism.

Various methods of treating the disease have been recommended with more or less success. If the disease is present in only a small number of birds they should at once be isolated and the pens from which they are moved should be thoroughly disinfected. The affected birds may then be treated individually, the scabs and exudate removed with forceps or by squeezing, and the exposed surface swabbed with a disinfectant such as tincture of iodine, or potas. permanganate, or touched with silver nitrate. Thorough disinfection of the premises and strict hygiene should be practised.

If, however, the flock is a large one in which the disease is spreading rapidly, such individual treatment is practically impossible. In such cases a preventive as well as curative is desirable, and vaccination has been resorted to for this purpose.

Various vaccines have been prepared and tried, but the one which seems to have given the best results is one that was first prepared in Europe in 1905. This vaccine has since been prepared and used with varied success in bad outbreaks in California, Wisconsin, Michigan, British Columbia and Ontario.

The vaccine is made from a mixture of the scabs and exudate taken from sick birds. This material is pulverized with pestle and mortar, a little sharp sand being thrown in to help the grinding process. This is then added to physiological salt solution (1 gram of salt to 100 c.c. of boiled water) at the rate of 1 gram of exudate to 200 c.c. of the physiological salt solution. After well mixing it is filtered through filter paper and the filtrate is then attenuated at a temperature of 55° C. for 1 hour. This attenuated filtrate is the vaccine and contains millions of bacteria of various species per c.c. One c.c. constitutes a dose for a bird and the treatment consists in injecting subcutaneously with a hypodermic syringe 1 c.c. of the vaccine. The place recommended for the injection is the skin of the breast just under the wing. A few feathers should be removed from the point of injection, and the surface wiped with a disinfectant before and after injection. A second injection is recommended 5-7 days after the first.

The writer tested this method of preventive and curative vaccination on more than three hundred birds housed in fourteen adjoining pens. A considerable number of these birds were suffering from the disease in all its stages. A vaccine was first prepared and used on thirty sick birds that had been isolated. Some of these birds appeared to be almost in a dying condition at the time of vaccination. On the third day after vaccination there was a very marked diarrhœa, and on the fourth day a general improvement in condition of the birds was noticed. This improvement continued until the time for a second vaccination.

A second vaccine was prepared in the same way as the first, but the material for this vaccine was taken from different birds from that used in the first vaccine.

A sufficient quantity of vaccine was prepared to treat the whole flock of over three hundred, in addition to those already vaccinated. For some reason or other not determined, this second vaccine did not have the same favorable results, neither on those birds which were receiving the second treatment, nor on those, whether they were sick or healthy, that were receiving treatment for the first time. A number of deaths occurred after a few days following the vaccination both of sick birds and birds that were healthy before vaccination. Post-mortem examination of these birds indicated death to be due to toxic action. It would appear that the material used for the second vaccine, although obtained in the same way as the material used for the first vaccine, but taken from different birds, had contained some toxic substance sufficiently strong to cause death of some of the birds on which it was used.

Thus, though the first vaccine prepared had a curative effect on the sick birds on which it was tried, the second vaccine appeared to have no curative effect on sick birds, and we could not consider that it had much preventive power, as a number of healthy birds that were treated with it contracted the disease later.

Therefore, while some report successful results being obtained for this method of vaccination both curatively and preventatively, we cannot give the method an unqualified approval.

There is more danger of the disease establishing itself and making headway in damp, muggy weather and when the floors of the pens and runs are wet or constantly damp, as is common in the springtime. These conditions, however, while they favor the disease cannot be considered as its cause.

"BLACKHEAD" OF TURKEYS, SPOTTED LIVER.
(*Infectious Enterohepatitis.*)

We occasionally get sick or dead turkey poults, half-grown turkeys and the diseased livers of adult turkeys that have been killed, sent us for examination. Almost invariably the disease from which these have been suffering is the one known commonly as "Blackhead" or Infectious Enterohepatitis. This is an infectious disease that is most fatal to turkey raising and is largely responsible for the dearth of turkeys at the present time, as compared with the numbers of years ago.

The disease is not due to bacteria but to a species of protozoa, an amoeba known as *Amoeba maleagridis*. This is a microscopic animal organism slightly larger than bacteria. It is considered that ordinary fowls harbor the parasite, but that they are not subject to the disease to the same extent as turkeys.

SYMPTOMS.—The disease is most common among turkey poults from two weeks to four months old. The affected birds lose their appetite and get dull and listless; diarrhoea develops, the wings and tail droop and the head gets darkly discolored, hence the common name of the disease "Blackhead."

The greater number of affected poults die before they reach four months of age. In other cases the disease assumes a chronic form, but the affected birds are never thrifty and never do well.

Post-mortem examination shows the caeca or blind pouches of the intestines to be swollen and inflamed, sometimes almost gangrenous, and filled with a rather hard cheesy exudate which adheres rather tenaciously to the inner lining of the caeca. Sometimes other parts of the intestine are inflamed. The liver will be more or less spotted with somewhate circular, flat or slightly sunken, straw-colored areas from a quarter of an inch to an inch in diameter, sharply defined from the rest of the liver tissue. These pale yellow spots may sometimes be mistaken for the tubercles of tuberculosis. The surface of the latter, however, is usually slightly raised above, instead of sunken below the surface of the surrounding liver tissue.

The amoeba which causes the disease is given off in large numbers in the droppings of affected birds, and so the disease is spread through a flock by the food and water contaminated by such droppings. On gaining entrance to the bird's digestive tract the amoeba establish themselves in the walls of the caeca, where they multiply and set up inflammation and migrate thence to the liver, where they multiply and produce the pale yellow-colored spots.

The disease has proved to be one of the most difficult ones to deal with satisfactorily. No treatment so far practised has shown very good curative results. Hence turkey raisers should prevent, as far as possible, the disease from getting established in their flocks by practising the strictest hygiene.

Foul Brood of Bees.

There are two varieties of foul brood of bees, one known as American Foul Brood, caused by *Bacillus larvae,* a resistant spore producer and the other known as European Foul Brood, caused by *Bacillus pluton,* which is not a spore producer.

American Foul Brood is common in United States, Canada, France, Germany, Switzerland, England, New Zealand and probably also in other countries.

It affects the larva and pupa of bees and is usually first visible about the time the larva fills the cell, after it has ceased feeding and is sealed over in the comb. The larva gradually sinks down in the cell and turns brown in color. If a mat h or bit of stick is inserted and withdrawn the larval remains adhere to it and string out in a slimy thread. The larval remains continue to dry down and gradually lose the sliminess until finally they become a mere scale at the bottom of the cell.

A characteristic odor something like heated glue is given off by the diseased larvæ.

Usually the disease attacks only worker broods, but occasional cases are found in which queen and drone broods are diseased.

Control.—Brood from badly diseased colonies should be burned. The swarm should be transferred from the infected hive to one that has been cleaned and disinfected. The combs from the infected hive should either be burned, melted or boiled thoroughly before the wax is used again. Infected hives should be burned over inside with a gasoline or oil torch.

European Foul Brood, also known as "black brood" or "New York" bee disease is not so widespread on the American continent as is the American Foul Brood. It is found pretty general in England, Germany and Switzerland. Wherever it develops it causes heavy losses to the honey industry.

Symptoms.—Diseased larva appears yellowish tinted or transparent instead of the bluish white or glistening white of healthy larva. The peristalsis-like motion of the bodies of sick larva is much more pronounced than that of healthy larva. Larva dying from this disease frequently show the segments of the body marked off less distinctly than living healthy larva.

Methods of Control.—Similar to those for American Foul Brood.

GROUP VII. BACTERIAL DISEASES OF PLANTS.

The bacterial diseases of plants fall naturally, according to the changes which they induce in the host plant, into four types, as follows: 1, Bacterial Soft Rots; 2, Bacterial Wilts; 3, Bacterial Canker or Blights; 4, Bacterial Galls.

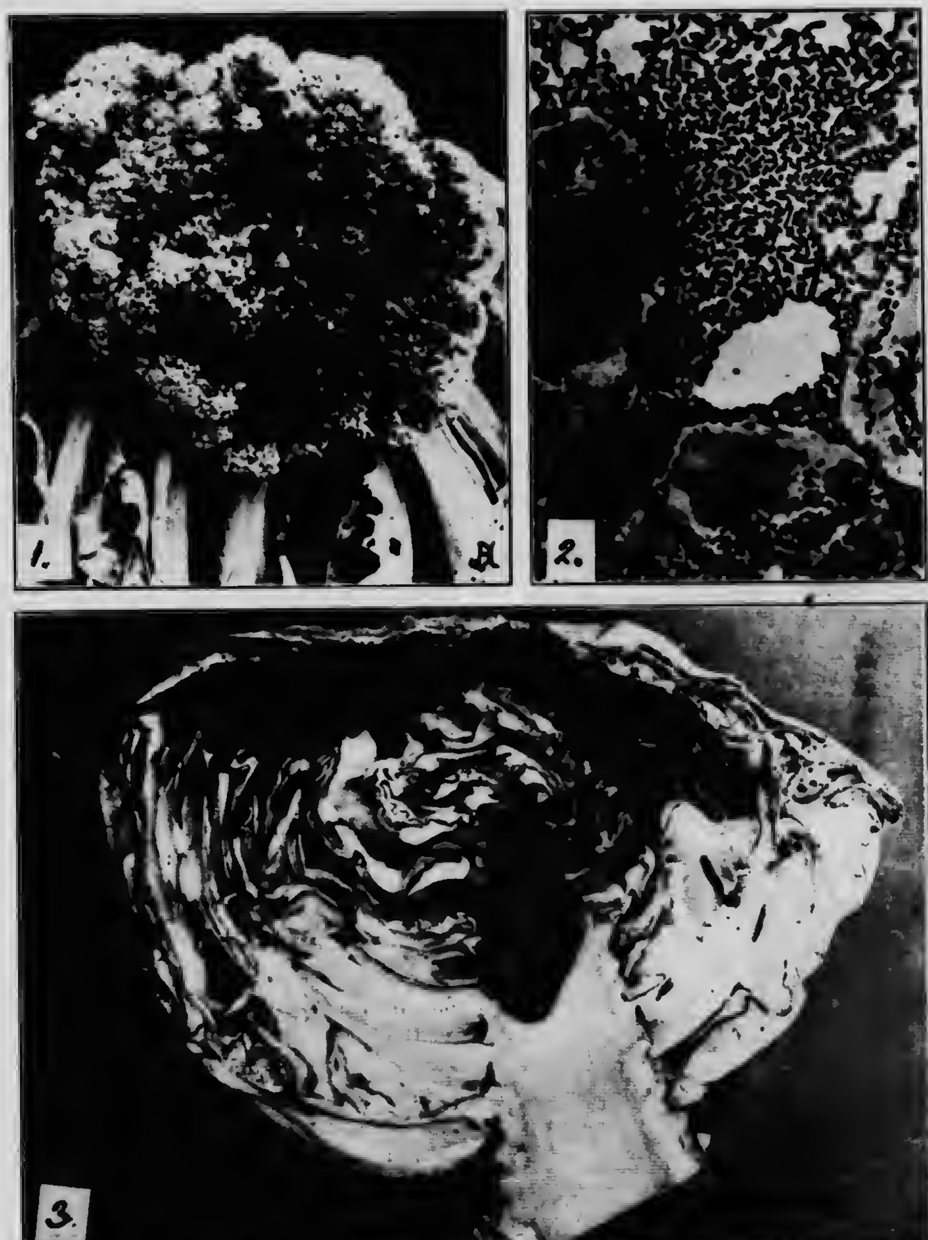
Bacterial Soft Rot of Vegetables.

Bacterial soft rot is a disease liable to attack fleshy vegetables and flowers, particularly carrots, cauliflower, turnips, celery, tomatoes, potatoes, German iris and calla lily, and in a lesser degree onions, asparagus, salsify, sugar beet, mangel, muskmelons, rutabaga, and some others. Occasionally the disease results in heavy losses to the grower of these crops.

General Appearance of the Disease.—As the name signifies, the disease results in a soft, wet rot of the plant attacked. The rotted portion of the plant is darker in color than the rest of the plant. The color of the diseased part varies from a light, reddish brown to a very dark brown.

The Cause of the Disease.—The cause of the disease is a bacillus which has been given a variety of names by different men, who at different times in various countries have studied the disease in different species of plants. Prof. L. R. Jones, of Vermont, studying the disease in a crop of carrots, named the causal organism *Bacillus carotovorus.* Prof. Harrison, of Ontario, studying the disease in an outbreak in a crop of cauliflower, named it *Bacillus oleraceae;* Prof. Potter, in England, studying the disease, found it to be destructive to quite a number of varieties of plants, and named it *Pseudomonas destructans;* N. J. Giddings, of Vermont, studying the disease in a crop of melons, named it *Bacillus melonis;* C. O. Townsend, of Washington, studying the disease in a greenhouse of calla lilies, named it *Bacillus aroideae.* More recent investigations have shown that the disease is practically one and the same in all the plants mentioned. While to the bacteriologist there may be a few slight differences in the nature of the bacillus causing the disease in the melon from that causing the disease in the lily, or that causing the disease in carrots, turnips and cauliflower and other vegetables, yet the disease is for all practical purposes to the horticulturist one and the same—a soft, wet rot of the plant attacked.

Histology of the Disease.—When the *soft rot bacillus* gets on to a freshly made wound, either small or large, in plants liable to the disease, it feeds on the plant juice which emerges on to the wounded surface, and on this it grows and rapidly multiplies. As it multiplies it produces digestive enzymes, e.g., cytase, which digests cellulose; diastase, which digests starch; and proteolytic enzymes, which digest proteids. These are diffused through the living bacterial cells and act upon the healthy vegetable tissue around them, making it soluble, to be used as food material by the bacilli. The action of these enzymes is greatest on the middle lamellae, i.e.. the thin strip of tissue which lies between the walls of adjacent plant cells. The lamellae are quickly dissolved and form good food for the multiplying bacilli, which, as they multiply, pass along between the cells, filling the intercellular spaces and separating the cells from one another. The protoplasm within the plant cell is plasmolised, that is, it is made to shrink from contact with the cell walls and to contract into an irregular mass within the cell by the action of the enzymes produced by the bacilli in the intercellular spaces. In this way the collapse of the tissue is brought about, and such tissue constitutes the rotted part of the plant.



Bacterial Soft Rot of Cauliflower and Cabbage. (Original.)

1. Bacterial soft rot of cauliflower, natural infection; specimen taken direct from garden.
2. *B. carotovorus*, the vegetable soft rot bacillus seen between cells of broken-down, rotting cauliflower. (X 1,000 di.).
3. Bacterial soft rot of cabbage. Artificial stab inoculation of a pure culture of *B. carotovorus* in healthy cabbage. Photo taken twenty days after inoculation.

In *cauliflower* the disease is found more often in the flower than in the leaves or stem; the latter parts, however, are also subject to attack.

The disease in the flower is very easily noticed, the normal color of the flower being white or creamy and that of the diseased portion light to dark brown and very soft, and having an offensive odor. The writer has noticed a number of times dark brown areas, varying in size, which looked at first sight like soft, rotted areas, but which on investigation proved to be discolorations due to excreta of cabbage caterpillars which had been feeding on the leaves overhanging the flower. In such cases the tissue immediately below the surface of the discolored area is not softened as it is in the case of the rot, and the discoloration is only on the surface. Observations have shown, however, in a number of such cases that the rot has later developed, within such discolored area, thus indicating that in all probability the caterpillar had previously been feeding on a rotted plant, and all the bacilli in the portion consumed had not been killed in the process of digestion, but had passed through the alimentary tract of the caterpillar with the excreta, or that the mouth parts and feet of the caterpillar had been contaminated from a diseased plant, and on crawling over the surface of the healthy plant had inoculated it.

In the stem the disease results in a complete softening of the interior, the softened tissue becoming a dirty grey in color, with strong odor. The disease may enter the stem from injury to the exterior caused by the breaking of leaves, or the biting of insects, slugs and caterpillars during cultivation, etc., and from the stem pass up into the flower, or the stem may become so far rotted that the head will fall off. The stem may also become infected through the flower.

In the leaves the disease is more often found in the petiole, or midrib, rather than the blade. It appears as a dirty grey softened area, which, when in the petiole, soon results in collapse of the leaf.

In *turnip,* the disease most frequently enters at or near the crown, through caterpillar or slug attack, or through injuries received during hoeing or cultivation. It softens or rots the leaf petioles at their base, causing them to fall over, and spreads slowly in dry weather, rapidly in wet weather, through the tissue of the root, inducing a brown-colored soft rot, with strong odor.

In *carrot* the disease enters and develops in much the same way as described for the turnip. It is more apt to spread rapidly through a crop that is thickly sown and not well thinned out, the shade produced by the heavy tops making ideal conditions by keeping the ground moist for the development of the disease when once it gains entrance, and harboring slugs and caterpillars that spread the disease. Carrots which crack beneath the ground are liable to be attacked by the disease, the soft rot bacillus gaining entrance to the tissues through the cracked surface.

In *celery* the disease is not very common, but when present is most often found starting at or near the tops of the young growth. The affected parts become dark brown and very soft and mushy. The parts so affected cease growing, the growing tips being destroyed, and the disease slowly passes down the stem, completely rotting the tissue as it progresses. If the disease starts below the end of the stem, the upper part soon topples over as a result of the softening of the part attacked. The disease spreads from plant to plant through the agency of slugs, caterpillars, etc., and during the process of handling when cultivating and banking up. When the plants are stored away for winter use, if a plant having the disease is stored with the healthy plants, the rot is liable to spread to the healthy specimens.

In *tomatoes* the bacterial soft rot is very common during wet seasons. It is found most frequently in the fruits that are in contact with the soil after they have commenced to ripen. The bacillus will not readily penetrate through the unbroken

Bacterial Soft Rot in Turnip. (Original.)

1. Turnips direct from field badly affected with bacterial soft rot. Shaded areas were soft, pulpy and strong smelling. Evidently inoculated near the crown, probably through wounds made by slugs or caterpillars or during cultivation.
2. Soft-rotting turnips direct from field, in which the disease had been prevalent the previous year. These had evidently been inoculated from the soil through wounds made while hoeing or cultivating.

skin of the tomato. But when a tomato is resting on the damp earth, that part of the skin in contact with the soil is frequently weakened, thus providing a means of access to the bacillus. This, however, is not the only means whereby the disease enters the fruit. Slugs are very partial to tomatoes just ripening. In their attack on the fruit they eat through the skin, leaving the interior flesh exposed. This exposed surface is an ideal medium for the bacillus of soft rot to develop in. The writer has found many tomatoes, particularly in wet seasons, when slugs are plentiful, that have contracted the disease in this way.

Eradication and Control of the Disease.—Spraying with fungicides, which is so effective in controlling the fungous diseases of plants, is of no avail with bacterial diseases, as the bacteria which cause the disease act in the interior tissue rather than on the surface; hence the spray will not reach them.

Spraying with insecticides is helpful indirectly, as it tends to keep in check the insects, slugs, caterpillars, etc., which are one of the most common means of spreading bacterial diseases from one plant to another.

As a rule, the best method to adopt in dealing with a plant infected with bacterial disease is to carefully remove and burn it. Insects, garden tools, etc., coming in contact with it will spread the disease to the plants with which they come in contact later. This is particularly the case with the bacterial soft rot of plants, as the affected tissue is so very soft and pulpy that it cannot be touched without heavily contaminating whatever touches it.

Again, if affected plants are allowed to remain on the ground they infect the soil with the organisms of the disease to such an extent as frequently to cause the disease to establish itself in the succeeding crop of any plants which are susceptible to the disease, but particularly plants of the same species.

Some time ago we received for examination a box of rotting, half-developed turnips from a farmer, who said that five per cent. of his crop were similarly affected. Upon inquiry, we found that the affected ones were growing on soil on which turnips had been grown the year previous, and 25 to 30 per cent. of these, having been affected with the same rot, had been allowed to remain on the ground at harvest time, and later were plowed in. It was evident that the soft rot bacilli from the diseased turnips had remained alive in large numbers in the soil, and that many of the turnips of the subsequent crop had been inoculated with these bacteria during cultivation, and possibly by insect attack also. The hoe or the teeth of the cultivator would get contaminated from the soil, and the accidental wounding of a turnip with such an implement would result in the inoculation of the turnip with the germs of the disease.

Another man sent a head of celery for examination, which we found to be suffering from the bacterial soft rot in the young growing tips. In reply to our enquiries, he sent word as follows: "I had celery on this ground two years ago, and the row that was where the rot is worst now was so bad that I lost all, but only that row was affected. This year two rows have it, but one a great deal worse than the other. There were five rows in this patch, all planted about the same time. The healthy rows matured away ahead of the two which were diseased." Here it is evident that the soft rot bacteria had remained in the soil for two years, and that cultivation had spread the bacilli to some extent through the soil, as on the second occasion that celery was grown on that patch the plants in two rows developed the disease.

The writer had under observation a garden where turnips and carrots were both affected with the bacterial soft rot. The affected plants were not removed, but were dug in. The next year tomatoes were planted on the same ground. The disease did not develop in the growing plants, as care was taken not to wound them. However, about 60 per cent. of the fruit became affected before it was fully ripe. The affected specimens were either those that were in contact with the soil or had been bitten by slugs. The soft rot bacteria, which cannot penetrate through the sound skin of a tomato, found entrance through the slug bites, or through the weakened skin that had been in contact with the soil.

Therefore, in order to prevent losses from bacterial soft rot of plants, remove and burn affected plants, or parts of plants, as soon as observed; be careful during cultivation not to wound plants, and keep caterpillars, slugs and biting insects in check. Affected plants should never be put on the compost heap or manure pile.

HARVESTING AND STORING.—When harvesting and storing turnips, cauliflower, cabbage, celery, tomatoes, or other vegetables from crops in which the disease has been present, great care should be taken not to include any specimen that shows the slightest appearance of the disease, or to smear the healthy specimen with the soft, rotted parts of diseased specimens. If these precautions are neglected, the disease is liable to establish itself and spread more or less rapidly through the entire crop stored.

BLACK LEG AND SOFT ROT OF POTATOES.

Causal organism—*Bacillus solanisaprus* (Harrison); *B. phytophthorus* (Appel).

As the name of this disease implies, there is a darkening of the lower stems and soft rot of affected plant. The discoloration may range from brown to black; usually it is dark brown. It is most often found below the soil surface from the seed tuber up, but may extend upwards an inch or two above the soil. The discolored part shrinks and is liable to rot.

The disease affects young plants more particularly and kills them off early in the season. A disease of this character is common in Europe, particularly in Germany, where it has been known for years. It is considered that it was introduced to the American continent from Europe on imported seed. It is spreading rapidly in Canada and the United States.

SYMPTOMS.—The tops of plants affected with the disease lose their bright green color, which fades away to a brownish or dirty yellowish green, presenting a withered and drooping appearance. On examining the lower stems of such plants, the brown or black discoloration will be noticed. In many cases such discolored tissue will be soft rotting, and an examination of the seed tuber usually shows it to have rotted away, with a soft, slimy, wet rot, often nothing but the skin being left. The soil underneath such a rotted seed tuber appears as though it had been wet puddled, due to the rapid extraction of water from the seed tuber during the rotting process. A microscopic examination of the soft rotting tissue, both in the seed tubers and the stems, shows large numbers of bacteria, usually several species being found in the older rotted parts.

If a number of shoots arise from an affected seed tuber, it is likely that one or more of them will develop the disease at an early date, while the others will flourish for a time and be apparently healthy. As they grow they will produce tubers, and, should the season be dry, these may reach maturity without being seriously affected. If the season is wet, however, the disease is most liable to spread to the healthy stems and tubers, thus establishing a soft, wet, slimy rot of the entire plant, tubers included.

In other cases of called black leg, where the stem of the plant is badly discolored, the soft rot may not be in evidence. A microscopic examination of the

Black Leg of Potato. (Original.)

discolored epidermis shows no bacteria, but strands of fungus mycelium, most of which presents the typical appearance of the fungus, *Rhizoctonia*, a species of fungus which is responsible for the root rot or canker of many vegetables. In some cases potato plants so affected appear later to get the better of the disease. That is, they do not die down or rot off; or, if some stems on the hill which are the worst affected die down, other stems not so badly affected, or not affected at all, develop apparently all right. However, later in the season, when the crops are harvested, hills which have very vigorous tops, heavy foliage and thick stems, may have also aerial tubers, that is, tubers as very irregular swellings on the stems above ground, and usually a large cluster of very small malformed tubers crowded together at the surface of the soil. Examination of the underground stems of such plants usually shows discolored, brown shrunken areas, which evidently have been affected by the *Rhizoctonia*. The theory which has been advanced regarding the formation of such heavy top growth and the production of aerial tubers on the stems of the plant, with large clusters of small malformed tubers at the crown, is that the growth of the fungus on the stems of the plant interferes with the transmission of the reserve food substance manufactured in the foliage which, under normal conditions, is returned to the roots, where it forms the tubers. The injury to the underground stems caused by the *Rhizoctonia* prevents the passage of this reserve food material to the usual parts of the root system and forces its deposition in abnormal places, either at the surface or above the surface of the soil in the shape of malformed tubers, which are usually small and numerous.

In many cases of the bacterial soft rotting type of black leg, the writer has found on the epidermis of the discolored stem, interlacing strands of *Rhizoctonia* mycelium. It is possible that this fungus is the primary cause of most cases of this disease, and that the bacterial soft rotting of the affected tissue in such cases is secondary, owing to an invasion of the weakened epidermis by the decay bacteria common in the soil.

The disease is most common in wet, backward seasons, when the resistance power of the young growing plant is low.

Control of the Disease.

1. Do not plant potatoes that show any brown discoloration, brown or black scab, or other indications of either wet or dry rot.
2. Plant in well-drained land.
3. Destroy by burning all diseased plants and tubers.

Bacterial Wilt of Cruciferae.

(Black Rot of Cabbage, Turnip, etc.)

Causal organism—*Ps. campestris.*

This wilt, commonly known as Black Rot of Cabbage and sometimes as Brown Rot, is a very bad disease and causes much loss to the kitchen gardener. It is found attacking many cruciferous plants, including cabbage, cauliflower, collards, kohl rabi, brussels sprouts, broccoli, turnips, wild radish, and mustard, the latter, unfortunately, only to a very slight extent.

It is widely distributed, occurring throughout Canada, United States, Great Britain, Holland, Germany, Denmark, Austria, France, Switzerland, and other countries.

Appearance of the Disease.—In the growing cabbage plant the disease manifests itself as a yellowing or browning of the leaves. This yellowing occurs in

Bacterial Wilt of Cruciferæ (Black Rot of Cabbage). (Original.)

1. Cabbage leaves affected with the bacterial wilt or black rot. The lighter-shaded areas around the outer edge of the leaves are the diseased parts showing natural inoculation through the water pores on the edge of the leaves; the light-shaded areas were yellow.
2. The lighter shaded part of the leaf near the base indicates the disease, and the blackened vascular bundles of the stem, where it is cut, indicates that the disease entered this leaf from the main stalk of the cabbage.
3. Cabbage stalk and stunted head; the blackened vascular bundles indicate that the disease was general throughout the plant. The leaf of Fig. 2 was taken from this plant.

Bacterial Wilt of Cruciferæ (Black Rot of Cabbage). (Original.)
1 and 2. Views in a cabbage plantation, showing numerous cases of the disease in all stages of development.

irregular areas sharply defined, which gradually enlarge until the whole leaf becomes browned, wilted and shrivelled.

If the plant be attacked by the disease when young it will not develop normally, but will be dwarfed, and will present a pale, sickly appearance, and often no head will be produced in the case of a cabbage, and no bottom produced in the case of a turnip.

The browning and wilting of the leaves is due to the supply of sap being cut off in the veins and midribs that are situated near or within the brown areas.

If the midrib of a diseased leaf or the veins leading from a diseased part of a leaf be cut, it will be noticed that the vascular bundles or fibres are black or dark brown, instead of yellow or white. This discoloration is due to the presence and action of immense numbers of the disease-producing bacteria within the veins or fibro-vascular bundles. Here they feed on the sap, multiply rapidly and choke up the passages, so that the supply of sap is cut off from the surrounding tissue, thus causing it to yellow, wilt and die.

If the whole head of cabbage be yellowish, sickly, and wilted, or if several leaves of a cabbage present such an appearance, a section of the stalk, either cross or longitudinal, will almost invariably reveal the disease in the blackened vascular bundles forming the vascular ring, the woody portion of the stem. In such a case the germs will have spread almost throughout the entire vascular system of the plant, passing down the veins of one leaf into the stem, where they would pass both up and down the veins of the stem, to veins of other leaves, until the whole plant became affected and worthless.

Means of Infection.—Infection is most common at the water pores around the margin of the leaf. In the early morning, especially in moist weather, dew-drop-like beads of water may be noticed around the leaf margins of growing cabbages. This is usually water of transpiration, given off by the plant through the water pores. If the atmosphere were dry, this water would not be found there, as it would evaporate as soon as it came to the surface of the plant. But when the atmosphere is moist this evaporation does not take place, and so the water extruded from the pores forms little beads.

Should the disease germs by any chance get into these drops of water, it is very easy for them to enter the vascular system of the plant through the open pores. Thousands of cases where such has been the means of entrance of the germs into a plant have been observed.

The question remains: How do the germs get into the drop of water? This may occur in several ways. Slugs and caterpillars crawling around after feeding on or crawling over a diseased plant may carry and deposit the germs wherever they crawl on the healthy plants. The cultivator, in passing along the rows, may brush against and wound a diseased plant and some of the germs thus get onto the cultivator, and so be carried along and brushed off on healthy plants. In transplanting, the hands of the workman may become contaminated from handling a diseased plant, and plants subsequently handled have the germs deposited on them from the hands of the workman. Even should the plant be dry at the time it is so contaminated, the germs may remain alive on the plant for days, until the right conditions occur, that is, sufficient moisture be present in the atmosphere and in the soil to allow of the formation of water drops at the water pores when infection would take place.

Again, biting insects, caterpillars, slugs, and other forms of animal life which feed on growing cabbages, may, after feeding on a diseased plant, inoculate directly a healthy plant by biting through one of the small leaf veins and depositing there some of the germs adhering to their mouth parts after their visit to the diseased plant. Such means of inoculation have been observed again and again. Caterpillars and slugs, feeding on diseased leaves, have been transferred by hand to healthy plants and in a large percentage of cases the disease has subsequently developed in the healthy plants at the point where the caterpillar was placed.

Infection through contaminated seed may occur. By a series of experiments, conducted at the New York Experiment Station, Geneva, it has been proven that the germ can live on dry seed for longer than nine months. Such contaminated seed when germinating is liable to infect the young plant, and cases of such infection may occur in seed beds.

Again, seed beds are often badly contaminated with the germ by spreading on them material from the manure pile or compost heap, where diseased plants have been deposited to rot. And while it is very doubtful that the germ enters the plant through the root hairs, any injury to the root, or leaves that are near the ground, may result in the inoculation of the plant with the disease. Caterpillars and slugs crawling over such soil would be very liable to inoculate the plants growing there by crawling over and feeding on them.

Control of the Disease.—The best way to keep the disease under control is to prevent its development.

Disinfecting the Seed.—It was proven at the Geneva station that germs on the seed may be killed without any injury to the seed by soaking it for fifteen minutes either in a corrosive sublimate solution or in formalin.

If corrosive sublimate is used, the strength of the solution should be one part corrosive sublimate to one thousand parts of water. The most convenient method of preparing this solution is to use the corrosive sublimate tablets sold by druggists for making disinfecting solutions. One tablet, costing one cent, is sufficient to make a pint of solution, which is about the quantity required to treat one pound of seed. The seed should be soaked in this solution fifteen minutes, and then spread out to dry.

If formalin is used the strength of the solution should be one part formalin (40 per cent. formaldehyde), to 240 parts of water, and the seed soaked for fifteen minutes.

A convenient method of treating the seed is to place it in a small bag, made of any loose cloth readily penetrated by water, and suspend the bag in the disinfecting solution for the required length of time. The seed should be dried without delay in the shade.

Handling Diseased Plants.—Should the disease be noticed among seedlings in the seed bed, the diseased plants should be removed and burned. If they are not burned the germs within them are liable in many ways to get transferred to the healthy stock, and so the disease be spread instead of being checked.

Seedlings that show signs of the disease should not be planted out. It is not usually of much service simply to break a diseased leaf from what appears to be an otherwise healthy plant. If the disease is confined to the marginal areas of the leaf entirely, then breaking off the leaf would prevent the rest of the plant from developing the disease. But, should the vascular bundles in the midrib of the leaf at the point of its contact with the plant stalk be discolored brown or black, we may take it for granted that the germs are already established in the vascular bundles of the stalk. So, after breaking off a diseased leaf, one should look to see if any discoloration of the vascular bundles exists, and should there be any, the whole plant should be destroyed.

If an entire bed, or a considerable portion of a bed be badly attacked, all the plants should be pulled and burnt and the broken leaves, etc., raked up and burnt also. Cabbage or turnips should not be planted again on such ground for one or two years.

Insects and caterpillars, slugs, etc., should be kept in check, as they are noted carriers of the disease germ by feeding on diseased plants and then going to healthy plants.

Bacterial Wilt of Cucurbits.

Causal organism—*Bacillus tracheiphilus.*

This will often cause serious losses to the growers of cucumbers, squashes, melons, and other cucurbits. Whole plantations of these plants are sometimes completely destroyed, and the disease will pass rapidly through a house of cucumbers.

A diseased plant loses its bright green color and turns to a dull, dirty yellowish green. The leaves and stems become flaccid and droop, hang down limp and lifeless, having lost all turgidity. The fruit, when affected, becomes soft and appears somewhat water-soaked, and if squeezed will readily yield to pressure, and often under such treatment the skin will rupture and a slimy, clear liquid will ooze out. If this liquid is touched with the finger or any instrument, it will be found to be viscid, slimy or gummy, and will string out in long strands. If a diseased stem is broken or cut, similar conditions will be found to exist, i.e., the plant juice will be viscid, slimy and will string out in long strands when the cut surface is scraped with a knife or rubbed with the finger.

This sliminess or viscidity is the most characteristic feature of the disease, for a plant may wilt for lack of moisture and present an appearance something like a diseased plant. But if such a plant be cut and its juice expressed, this juice will prove to be quite watery and will not draw out in threads.

A microscopic analysis of the slimy juice from a diseased plant will show millions of bacteria within the smallest drop that can be obtained; while a similar preparation made from the juice of a healthy plant or a plant that has wilted merely from the lack of moisture will not show a single germ.

If a little of this slimy juice from a diseased plant be transferred on the point of a needle to the inner tissue of a healthy plant, by puncturing the healthy plant with the contaminated needle, in a day or two the plant will wilt, the bacteria inserted on the point of the needle having multiplied so rapidly and spread through the vascular system of the plant.

Pure cultures of the germ on artificial media are rather difficult to obtain as the germ will not grow readily on the ordinary media. However, pure cultures have been obtained on special media, and these inoculated into healthy plants have rapidly produced the disease.

In the stem and leaf the disease germ is found mostly in the vascular bundles, in the plant juice of which it lives and multiplies rapidly, spreading up and down and plugging the sap channels. Eventually the walls of the vascular bundles are broken down and the organism gets into the surrounding tissue to a limited extent.

The flesh of diseased fruit is transparent and water-soaked in appearance.

The plant juice in all affected parts becomes slimy or viscid and strings out in long strands.

Methods of Spreading.—1. The disease is spread from plant to plant mostly by biting and sucking insects, particularly the striped cucumber beetle and squash

Bacterial Wilt of Cucurbits. (Original.)

1. Bacterial wilt of cucumber.
2. Bacterial wilt of cucumber.
3. Bacterial wilt of squash.
4. Stained microscope preparation from the viscous slimy exudate of a vascular bundle of a wilting cucumber plant, showing the bacteria (*B. tracheiphilus*). (X 1,000 di.).

bug. These insects, after feeding on a diseased plant, have their mouth parts covered with the germs of the disease and on subsequently feeding on healthy plants, they inoculate the healthy tissue with the disease.

2. The gardener, in removing and destroying the diseased plants, cannot help but get his hands and the tools used badly contaminated with the disease germs, even when exercising the greatest care, and so, if he does not take the precaution to disinfect his hands and the tools used before handling any healthy plants, he is very likely to inoculate them with the germs of the disease.

Methods of Control.—All diseased plants should be carefully removed and burned immediately. If they are allowed to lie around, insects will swarm about them, get themselves contaminated with the germs and thus spread the disease wherever they go.

Hands and tools used in removing and destroying diseased plants should be thoroughly disinfected by washing them in five per cent. carbolic acid, or in corrosive sublimate of a strength one to one thousand, or some other good disinfectant.

Biting and sucking insects, especially the striped cucumber beetle and squash bug, should be kept under control by spraying and hand picking.

Bean Blight.

(Bacteriosis of Beans.)

Causal organism—*Ps. phaseoli* (Smith).

Whilst there has been no record of heavy losses from this disease in Ontario, we get every year bean plants suffering from the disease forwarded to us. Letters accompanying these plants often state that considerable damage was done to fields from which the plants were taken, many plants being attacked in the same way. Scarcely a season passes but what more or less of this disease is present in the beans of the College garden and in the bean plots in the experimental grounds. In the United States, where wax beans and lima beans are grown extensively, heavy losses are caused by the disease, and it is getting more general in Ontario.

The disease may be found on the foliage, the stems, the pods, and the beans within the pods. At first the disease on the pods appears as small, water-soaked areas. These areas gradually enlarge and usually are outlined by a reddish-brown border. As the disease progresses and the areas continue to enlarge, the whole of the affected area becomes a light brown, and does not develop the black or pink color or the sunken spots produced by anthracnose. The foliage becomes spotted and yellowed in large areas of the leaf surface, soon withers and falls away.

Method of Infection.—*Leaves.* The disease usually begins at the margin of the leaf, or where the leaf has been torn by insects, wind or hail. Here the germs find entrance into the plant tissues through the wound. A yellow spot is formed and the green color destroyed. The spot increases in size rather slowly, and the diseased tissue becomes brown and papery, turning dry and brittle in the sun and soft in the rain, and then is often torn away, leaving ragged margins and holes in the leaf. The whole leaf may die and fall to the ground or remain withered on the stem.

Stems and Pods. The disease usually enters the stem by way of the leaf stalk, and advances in the stem to other leaves and to 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 by irregular brownish areas, outlined by the characteristic red-

Bacteriosis of Beans. (Original.)

1. Diseased pods.
2. Diseased beans from diseased pods.
3. Healthy beans.
4. Bean plant badly affected with bacteriosis in foliage and pods.
5. *Ps. phaseoli*, the cause of the disease.

dish-brown margin. The beans may be apparently sound or only slightly discolored, or they may be much discolored. The whole plant does not usually die outright, but lingers through the season. Separate infections may occur at any place on pod or stem.

Seed Beans. In germination tests of diseased beans, less than half the number sown germinated. The remainder rotted. Those that germinated never produced healthy plants, but plants that were weak and soon wilted. Healthy seed sown under the same conditions germinated ninety-eight per cent., and produced vigorous, healthy plants.

The germs live over winter in the bean tissue and infect the plant on germination.

In appearance the diesase is somewhat similar to bean anthracnose or "pod spot" caused by the fungus *Collitotrichium lindimuthianum*, but this latter may be distinguished by its making rather deep pits in the affected areas which are pinkish and produce spore-bearing pimples.

Eradication and Control.—Do not sow seed from diseased plants. Do not sow seed that is shrivelled or has a brown varnish on surface. Remove infected plants and burn them.

"Fire Blight," Pear Blight, Bacterial Blight of Apple, Pear and Quince Trees.

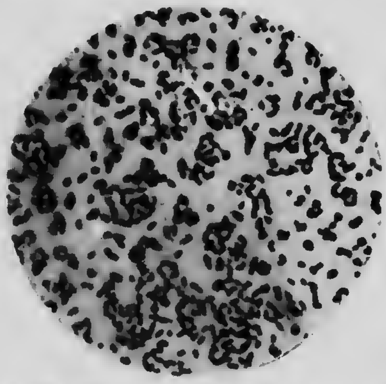
The disease which is known under the various names of Fire Blight, Twig Blight, Blight Canker, Pear Blight, and possibly others of local application, is of long standing on the North American continent. It has wholly destroyed many pear orchards, and has been very destructive to the apple and quince crops in nearly all parts of Canada and the United States, where these fruits are cultivated. Other trees besides the apple, pear and quince, both cultivated and wild varieties, subject to the disease, are the hawthorn (crataegus), June berry (Amelanchier) and the mountain ash (Pyrus).

The disease is caused by *Bacillus amylovorus* (Burrill), and is confined mainly to the growing bark which becomes cankered and then dies as a result of the bacilli multiplying rapidly between the growing tissue cells and later within the cells of the affected area.

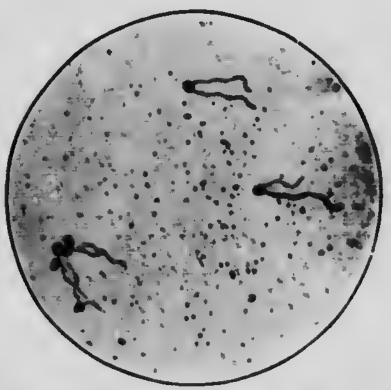
General Appearance of the Disease.—The disease may occur in the bark of the twig, fruit spur, branch or trunk of the tree and also in the fruit, more especially in immature fruit. Any one or all of these parts in the same tree may be affected, and the disease may spread from one part to another.

The disease is found on the apple tree more often in the form of twig blight, and on the pear tree in the form of body blight. Cases of body blight, however, occur in apple trees and cases of twig blight occur in pear trees. The reason that body blight is more common in pear trees appears to be because the bark of the pear tree is more spongy, thicker and more juicy than is the bark of the apple tree, and these conditions are most favorable for the rapid and continuous development of the organism. These conditions exist in the young growth, i.e., the twigs, water sprouts and suckers of the apple tree; hence when the organism finds entrance to these parts the disease develops there and passes up or down the affected part until it meets with adverse conditions, which it usually finds in the bark of the larger branches or the trunk of the tree at the end of the growing season. And so, as a rule, it is only the young growth of the apple tree that is destroyed by the disease, and the tree affected survives the repeated attack from year to year, until eventually it may become so impoverished from having its young growth annually killed that it will cease to be profitable and so call for removal. The disease, too, may find suitable conditions in the apple tree for its continued development in the bark of the large limbs and trunk where it causes large "blight cankers" com-

B. amylovorus, a smear preparation made by macerating a little of the inner bark of a diseased apple twig from which the viscid liquid was oozing.
Stained carbol fuchsin. X 1,000. (Original.)



B. amylovorus, smear stain from colony on agar four days old.
Stained carbol fuchsin. X 1,000. (Original.)



B. amylovorus stained to show flagella; made from an agar culture seven days old.

Moore's modification of Loeffler's flagella stain. X 1,000. (Original.)

Typical blight canker at the base of a water-sprout on the main limb of an apple tree. O.A.C. orchard. The water-sprout had been inoculated by aphids coming to it from a diseased tree. (Original.)

pletely girdling the affected parts and so destroying them, and thus causing the death of the tree. With the pear tree, on the other hand, as already stated, the disease, when once it gains entrance, usually spreads rapidly; it may destroy a tree in one season, and usually three years is the limit of life of a tree after it has once contracted the disease unless radical measures are taken to remove all affected parts.

THE DISEASE IN THE TWIG.—This phase of the disease is known as twig blight, or fire blight; the latter because a tree so affected looks as if it had been scorched by fire It may occur in blossom twigs, foliage twigs, water-sprouts and suckers. The blossoms and leaves of affected twigs become discolored, turning light or dark brown, sometimes red, shrivel up and die, and remain attached to the twig sometimes throughout the winter.

This discoloration and death of the leaves and blossoms occurs comparatively suddenly, and may occur at any time from May to September. The suddenness of its appearance is somewhat disconcerting to the fruit grower, who may walk through the orchard one day and find his trees looking apparently all right, but in visiting them again a few days later he finds many blossoms and leaves dry, brown and shrivelled. This discoloration and death of the leaves and blossoms does not mark the beginning of the disease, but rather its last stages in those parts so affected, and the disease will have been present in such twigs several days, often a week or more, before it is noticed by the casual observer. Hence, the disease is not so sudden in its onslaught as is popularly supposed.

If the bark of twigs that bear the discolored leaves and blossoms be cut and examined, the affected area will be found to be shrunken and discolored a dark reddish brown, or purplish. Sometimes the bark will be blistered and often on such blistered areas there will be present the somewhat dried remains of a gummy exudate. This gummy exudate bursts through the blistering areas or oozes through the pores of the bark when the disease is actively progressing in an area that is well charged with sap. On first appearing, the exudate is transparent and almost colorless, but as the moisture evaporates from it, it becomes first amber color, then brown, and finally a dark reddish brown when dry.

This exudate is literally crowded with the germs of the disease, and if by any means, either by insect, workman's tools, or careless handling of diseased parts, it finds entrance to the bark of a healthy tree, there the disease will develop.

The disease usually begins at the tip of the twig or in the blossom and works downward. The bacillus lives in the intercellular spaces and cells of the inner bark, feeds on the cell contents, and, as it develops and multiplies, passes along from cell to cell, destroying the tissue as it progresses. It may travel down the twig at the rate of from a quarter of an inch to two inches a day, the rate of its progress depending largely upon the succulency of the twig and the atmospheric temperature. The more juicy the twig, the more rapid the development, and warm days are more favorable to the progress of the disease than cold days.

On reaching the base of the twig, the disease may pass into the branch bearing the twig and from this point it may progress both up and down the branch. It often girdles the branch, and when such girdling occurs the flow of sap is prevented from reaching the upper part of the branch, which consequently slowly dies for lack of nourishment. The appearance of the leaves, fruit, and bark of a branch so affected is different from that of the same parts on diseased areas themselves. The leaves slowly lose their green color, the fruit slowly dries up, does not become decayed, soft and pulpy, and the bark does not discolor and shrink so rapidly as does bark that is diseased. If a portion of diseased bark be stripped from the twig with a knife, the brown discoloration will be found to extend right through the bark, and the surface of the wood itself is usually stained the same hue. The bacteria will be found to extend in all directions within the bark some distance beyond the discolored area.

THE DISEASE IN THE FRUIT.—The disease is often found in immature, but seldom found in mature fruit. It may find entrance to the fruit by way of the peduncle from a diseased twig or fruit spur, in which case the disease would spread from the core outwards. Or it may find entrance by puncture of the skin by insect or other means, when the disease would work from without inward. Such cases have not been observed to be numerous, though some such were examined, and experiments in the laboratory showed that puncturing the skin of a young apple with a needle dipped into the gummy exudate from a diseased tree, or into a pure culture of the germ, resulted in the complete destruction of the fruit in from two to three weeks. Mere contact of the germ on the fruit, however, did not result

Blighted apple twig: inoculation through blossoms on the two end spurs, presumably by bees. Disease passed down pedicels to spur, then to twig, killing the end of the twig. Apples developed below the diseased area, but the disease later passing further down the twig would prevent their maturing. (Original.)

Apple twig with two blighted spurs. These inoculated through the blossom. The disease had passed from the spurs to the twig, and when photographed the twig was girdled by the disease near the spurs and the apples and leaves at the tip had ceased developing and would soon wither.

in the development of the disease. Several experiments were made to test this possible means of infection, e.g., the gummy exudate, and pure cultures of the germ were copiously smeared on the surface of sound fruits, but without success.

The exterior of a diseased young apple or pear will be discolored light brown at first, then dark brown, and finally black. As the disease progresses, the flesh will become soft and pulpy, and the skin will become somewhat wrinkled. If the fruit be sectioned, the diseased part of the flesh will be soft and present a slimy and decayed appearance, discolored any shade of brown to black. Microscopic smear preparations of this broken down tissue or of the slimy fluid reveal dense swarms of the bacillus, and paraffin sections show the cells to be impregnated with the germ. Sometimes this slimy liquid oozes through the pores or through insect punctures of the skin in the same way that the gummy exudate emerges from the diseased areas on the twigs, limbs or trunks of the trees. When so exposed, insects alighting on the fruit get contaminated with it, and, as it is crowded with the disease germs, when the insects fly away they carry the germs along with them, especially on their feet and mouth parts. The disease spreads rapidly in the tissue of a young fruit, but slowly in a fruit that is ripening. In the latter case, the diseased area does not become slimy, soft and pulpy, but becomes discolored brown, having somewhat the appearance of a bruise, but the discolored tissue is not tough, as is that of bruised tissue. As the spur, twig or branch bearing the diseased fruit dies from the disease, thus preventing the flow of sap to the fruit, such fruit slowly dries out, becomes deeply indented with wrinkles, turns black or dark gray, and dull, and becomes quite hard. Such fruit will often remain on the tree through the winter.

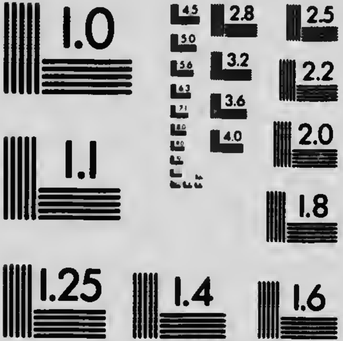
The Disease in the Main Limbs and Trunk.—1. *In the Apple Tree.*—Where the disease occurs in the main limbs or trunk of the apple tree, it is usually confined to a well-defined and limited area. This is the phase of the disease called "Blight Canker." Fully ninety per cent. of such infections are due to twigs, water-sprouts, and suckers being primarily inoculated. Down these latter the disease progresses until it reaches their base from which it usually spreads in all directions within the bark of the larger growth. So long as suitable conditions are obtained in the older growth, the disease will continue to spread there. While the disease is active, the bark affected will usually be a little darker in color than the healthy bark and will usually appear somewhat moist, as if water soaked. Sometimes it will be slightly raised and, if there be plenty of sap in the bark, it will usually blister, and the characteristic gummy matter loaded with the germs will exude. As soon as unfavorable conditions obtain, as, for instance, a diminution of the sap supply which may be induced by lack of cultivation, drought, or cold weather, the progress of the disease is checked, the germs present consume all the food material in the affected area, and being unable to get more owing to the resistance of the surrounding tissue to their invasion, they gradually die out from lack of nourishment. When the disease ceases to be active, the affected bark shrinks and subsides, and in doing so it is torn from the healthy tissue surrounding it and a crack is thus formed, usually entirely encircling the dead portion.

When cut with a knife, the diseased bark will appear brown, while the healthy bark surrounding it will be pale green or creamy white in color, and the line of demarcation between these is usually sharp and distinct. The dead bark is very tough. Sometimes germs will have pushed beyond the well-defined, cankered area, and will remain alive but not very active in the apparently healthy tissue until favorable conditions once more obtain, when they will resume their activity and another cankered area surrounding the old one will thus be produced. Sometimes a series of such cankered areas will develop, due to a repetition of the necessary conditions for growth, each crack separating one cankered area from the others, representing the termination of a period of activity. Blight canker may develop at the base of the trunk or crown, from infected suckers, also from injuries with contaminated cultivators.

2. *In the Pear Tree.*—As above intimated, while the disease does not cause so much loss by its development in the bark of the trunk and main limbs of apple

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



Cluster of water-sprouts on apple tree in which the blight is rapidly spreading, being carried from twig to twig by the aphids. (Original.)

Water-sprouts on apple tree in similar condition to those shown in preceding figure. (Original.)

trees as it does in the twigs and smaller branches of the same, with the pear it is the reverse conditions that prevail.

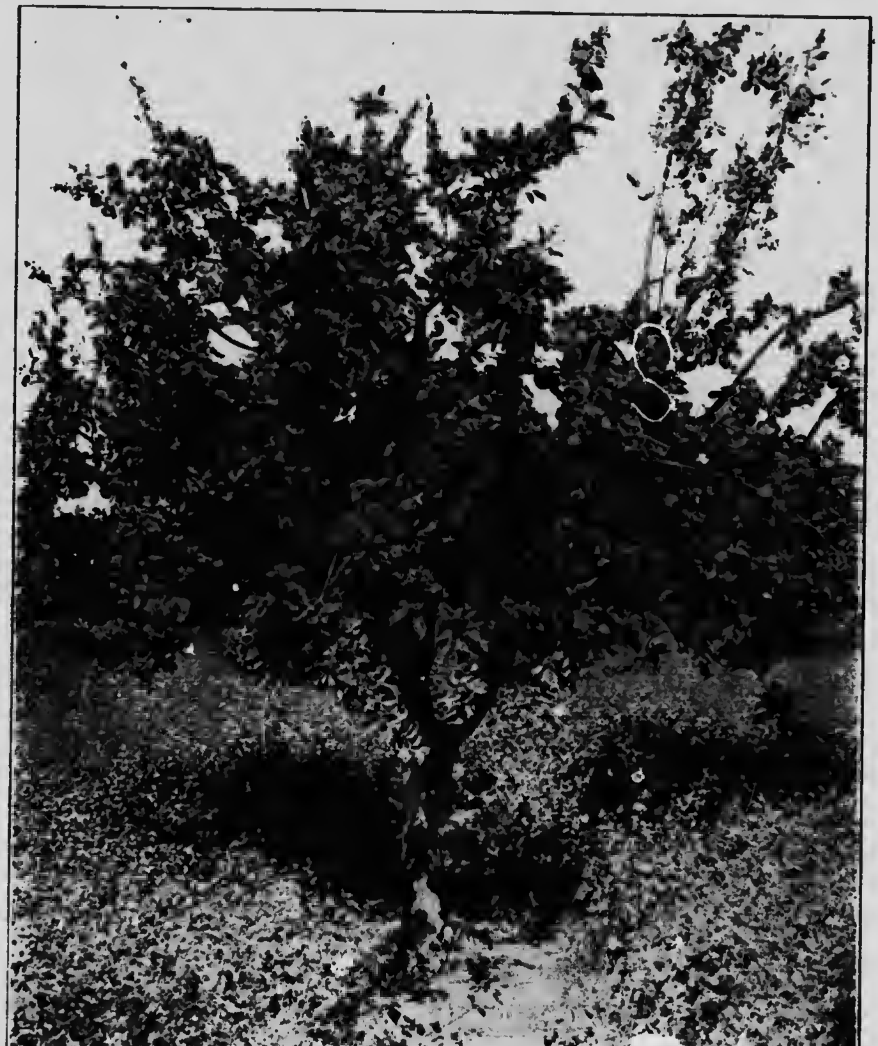
When once the germ finds entrance to the bark of a main limb or trunk of a pear tree, it seldom dies out until the whole tree is dead, unless the diseased area is radically removed. Especially is this the case with the choicer varieties of pears —the Duchess, Bartlett, Flemish Beauty, Clapp's Favorite and Clarigeau, for instance. When once these trees are attacked they seldom live more than three years if the disease is allowed to have its way.

The disease develops and spreads in the main limbs and trunks of pear trees in much the same manner as in the twigs. The exterior of the bark becomes discolored, sometimes brown and sometimes purplish. It often blisters and cracks and amber-colored gummy exudate emerges when the disease is most active. This may often be seen flowing slowly down the face of the diseased area. The disease

Large blight canker rapidly spreading in crotch of main limbs of Romenskœ apple tree, O.A.C. orchard. The whole of this canker developed in two months after inoculation by aphids through a water-sprout. Just above the centre of the picture is a small canker spreading at the base of a water-sprout also inoculated by aphids; and at the extreme right may be seen a long narrow sunken area running down the limb; this is a portion of a large canker formed at the base of a water-sprout, also aphid inoculated. (Original.)

is much less active during the winter than during the summer, though the complete cessation of its activity during the cold period is questionable. In the spring the tissue surrounding the dead cankered areas is teeming with the disease germs, which, on the flow of sap, begin rapidly to develop and spread farther afield. The disease is irregular in its progress. It may spread in any direction, and the cracks mark its periods of activity, and may be longitudinal or horizontal, but are seldom oval or circular as in the case of the apple. These periods of activity vary in duration, depending somewhat upon climatic and soil conditions which regulate the flow of sap—more sap, more disease, if the germ be in the tree.

It is this fact that is responsible for the idea that so largely prevails among pome fruit growers, that orchards under cultivation are more subject to the blight than are orchards in sod. The trees in orchards that are fertilized and cultivated naturally produce more young growth, and are more sappy than those in sod, and this condition being the most favorable for the rapid development of the organism. should it be present in the trees, the spread of the disease in these trees is much more noticeable than in trees that are less thrifty. Pear orchards may be in sod a number of years and the disease be present in the trees, but progressing so slowly as to be scarcely noticed by the owner. At length the owner decides to plough up the sod and cultivate. This results in the greater flow of sap in the trees, produces



Mature apple tree (Romenskœ) badly affected with twig blight. (Original.)

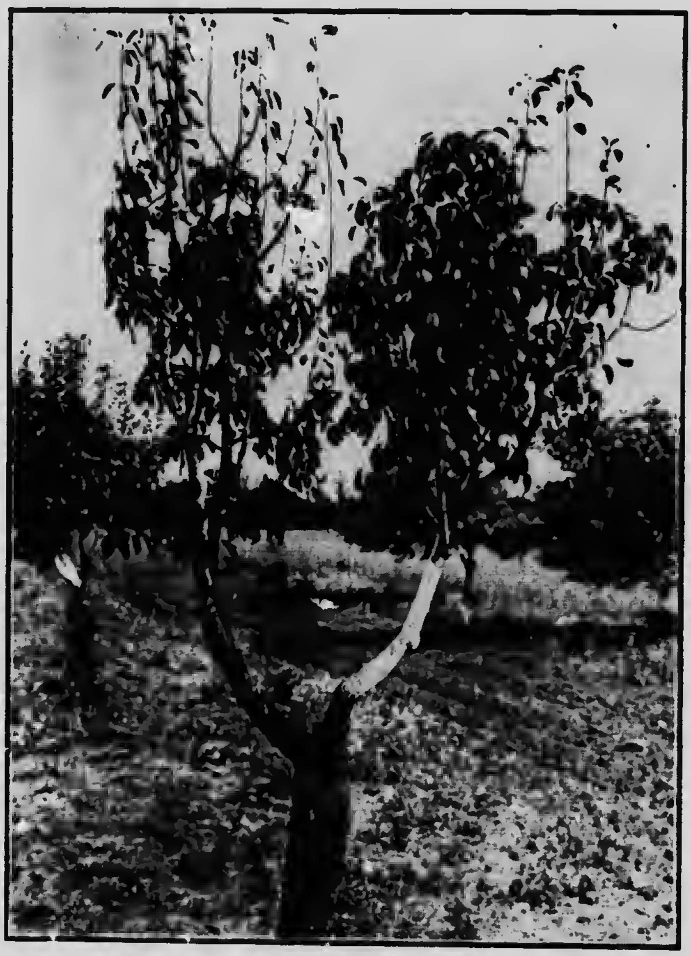
ideal conditions for the rapid development of the disease, and before the season is over, dead limbs and dead trees are seen in all directions. The owner, disgusted, destroys the dead material and allows the orchard to return once more to sod, deeming it better to have a decreased yield of fruit than to have the trees killed out wholesale. The spread of the disease slowly subsides, falls to proportions in which it is not very noticeable, and the owner decides that the attack of the disease

Cross section of a diseased young apple, showing cells filled with bacteria—*B. amylovorus*. Section 4 microns thick, stained carbol fuchsin. X 1,000. (Original.)

Cross section of a diseased young apple, showing bacteria within the cells. Section 4 microns thick, stained carbol fuchsin. X 1,000. (Original.)

was due to the cultivation, which, of course, indirectly it was. A number of such cases have come directly before our notice.

Sod, however, is not an ideal condition for an orchard. It means a diminished supply and an inferior quality of fruit, and it is a nursery for numerous of our insect pests. This being the case, what is the pome grower to do? The best thing is to find a more direct method of attacking the blight than merely diminishing its spread by leaving the orchard in sod.



Diseased Bartlett pear tree. Disease active in this tree four years; dead limbs cut away from time to time. (Limb to the left died this season. Limb to the right badly diseased. (Original.)

Dissemination of the Disease.—The disease is spread in various ways, e.g., by insects, pruning tools, cultivators, heavy rain storms. The most common way in which the disease is carried from tree to tree and from orchard to orchard is by insects.

I. Insects—(1) *Flower Visiting Insects.*—Bees, wasps and flies that visit the blossoms in search of nectar are responsible for most, if not all cases of blossom infection. A very large percentage of cases of the disease are due to infection

Main limbs of a Flemish Beauty pear tree, O.A.C. orchard, in which the blight is rapidly spreading. The limb to the right is practically dead. Notice the cracking and blistering of the bark, especially on the middle limb. All the disease above the crotch developed this season from the cankered area below the crotch. It spread throughout the bark very rapidly during June, July and August. Photo taken in September. (Original.)

through the blossom. These insects, after getting their mouth parts and legs contaminated with the bacteria from a diseased tree, carry the disease to the flowers of healthy trees, and as they burrow down into the flower to get the nectar, some of the bacteria are left in the nectaries of the flower. Here they find suitable food for their development and multiplication, and as they multiply they pass down the bark of the blossom peduncle to the bark of the fruit spur, killing tissue as they advance. They continue on down the bark of the fruit spur to the twig or branch on which the fruit spur is growing, and so the disease develops and kills the parts affected, as previously described.

(2) *Sucking Insects* that puncture the bark, such as aphids and jassids or plant lice, frequently spread the disease from branch to branch and from tree to tree in an orchard. These are responsible for many cases of the disease starting in suckers, water-sprouts, and young twigs that have no flowers, also for much of the infection of young trees in nurseries.

(3) *Boring Insects,* such as the shot-hole bark-boring beetle, have been shown to spread the disease among pear trees, both young and mature.

II. Pruning Saws, Knives and Shears.—Many cases of the disease in apple and pear trees have been established following innoculation of the pruning tools, by cutting through a diseased branch and then through a healthy branch, the latter becoming inoculated from the contaminated pruning tool.

Eradication and Control of the Disease.—The apple and pear blight at present is confined to the North American continent. Arguing from the point, no germ no disease, what is needed to stamp the disease out of existence is simply to destroy all the fire-blight germs in the country. This is very difficult to achieve, as the necessary concerted action on the part of all those growing fruits liable to the disease is practically impossible to obtain. However, concerted action on the part of all resident in a given district will be sufficient to so reduce the disease in that district that its presence will scarcely be noticed, if it is not indeed entirely stamped out.

1. *Cut out the Diseased Parts.*—In the first place, let it clearly be understood that when once the disease enters a tree, whether it be in twi[illegible] branch or trunk, there is no remedy for the part affected. The only measure [illegible]ed is to cut out the affected part and burn it right away. To cut off [illegible]d twig will save the limb on which it grows; to cut out an affected lar[illegible] [illegible]ill save the trunk; and if the trunk be affected in only a limited are[illegible]moval of the entire area of affected bark or canker will save a tree.

In cutting dead or diseased tissue from a tree, care must be taken to cut from several inches to a foot below the blighted area, so as to ensure the removal of all affected tissue. As previously pointed out, the germs are not confined to the visibly affected part, but are penetrating within the bark in all directions for varying distances beyond what can be seen to be affected. If only the visibly cankered area be removed, these germs are still left in the tree and the disease will continue to progress in the limb from which the cankered area is cut.

The best time to cut out blight is the first time it is seen. Every case of active blight is a potent source of infection for innumerable other cases. However, it is not always practicable to locate every case of blight as it occurs.

If systematic action in cutting out blight from an orchard be left until the regular pruning season, we would recommend that if one man is to do the pruning, he cut out all the diseased parts first before touching healthy limbs. Aso, that he disinfect his knife, shears or saw after every cut made on a diseased limb. This disinfec is easily accomplished by using a swab of cotton dipped in corrosive sublima.., strength 1-1000, which may be carried in a well-corked bottle. The swab may be on the end of a stick or piece of wire passing through the cork. If two men are engaged in the pruning operations, one of them should confine himself to removing the diseased limbs while the other operates only on the healthy limbs. All dead or diseased branches that are removed should be carefully gathered and burned at once.

Controlling Insects that Carry Fire Blight.—Not much can be done with regard to controlling the honey bees. In some of the Western States there has almost been war between the fruit men and honey men over this problem. It is not, however, the tame bee alone that is responsible for the dissemination of the disease among the blossoms, but the wild bees, wasps, ants, and other flower-visiting insects are found equally guilty. Then, of course, pollenation is brought about by the activities of these insects, and their services in this connection cannot be dispensed with.

If we are to prevent the flower-visiting insects from spreading the disease, the best way to do this is to remove all cases of the disease so that there shall not be any chance of the insects getting contaminated with the disease germs.

With aphids, however, the case is different. They are lawful enemies at all times. To keep them in check, destroy the eggs which are found on the twigs and smaller branches in the spring, by spraying with home-boiled lime sulphur, preferably of the strength of twenty-five pounds lime, twenty pounds sulphur, to forty gallons of water. As it is seldom possible to destroy all the eggs with any wash, it will be well to observe the buds as they are bursting, and see whether any of the little green insects are present. If so, use kerosene emulsion of the ordinary strength for summer wash. To get good results, thorough work must be done. In the fall of the year observe if any aphids are present on the water-sprouts, and if present, cut out the water-sprouts and burn them.

Many nursery trees are destroyed by fire-blight, after being inoculated by contaminated aphids. Therefore, as soon as aphids are observed in the nursery rows, carry a pail of kerosene emulsion along and dip the affected trees right into it.

To prevent the disease being spread by the shot-hole boring beetles, no dead or diseased wood should be allowed to remain in or near the orchard, but should be burned as soon as removed from the trees. The reason for this is that the beetles and their larvæ winter over in such wood, and unless destroyed will issue forth in the spring to attack trees in the orchard.

Crown Gall and Hairy Root of Plants.

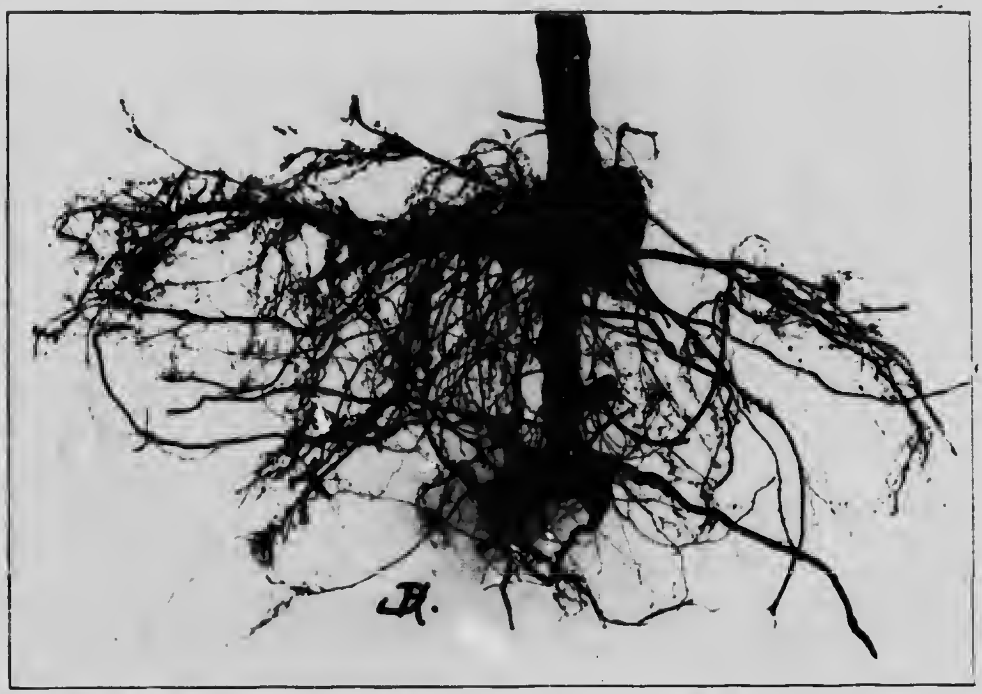
Casual organism—*Ps. tumefaciens Smith.*

Crown Gall and Hairy Root are two forms of one bacterial plant disease. The disease affects many woody and herbaceous plants. It has caused heavy financial losses in the cultivation of almonds, peaches, apples, quinces, raspberries, grapes and roses, and is found present in many other species of plants. It is common in Europe, the United States, South America and Canada, and has also been reported from South Africa. It is probably present in other fruit-growing countries.

When the bacteria that cause the disease gain entrance to the root tissue, they cause the development of tumors or galls or else the production of tufts of thin fibrous hairy roots. These conditions interfere with the feeding activities of the roots, also the transfer of food from the roots to the rest of the plant, and so lower the value of the plant by cutting down its production, finally making the plant worthless.

The formation of the galls and hairy roots is due to an abnormal increase of the growing plant tissue cells where the bacteria are active. It is considered that the acids and other by-products of the b- terial development are responsible for stimulating the tissue cells to this abnormal multiplication.

The galls may be hard and woody, or they may be comparatively soft. The hard and woody galls are due to the presence of twisted and contorted vascular bundles and woody fibres within the body of the gall. The soft galls consist almost entirely of parenchymatous tissue with very little vascular tissue combined and this is very thin walled.



Crown gall and hairy root on young apple tree received in nursery stock. (Ori_ .).

The soft galls, or parts of them, may decay, crumble up and slough off at any period. This is considered to be due to the fact that owing to there being but little vascular tissue in the gall, and this being twisted irregularly through the mass, there is not sufficient moisture conveyed to the cells to keep them alive and growing, consequently, they die and crumble away. A portion of diseased tissue, however, is usually left, and this causes a recurrence of the gall. In the case of hard galls, this sloughing off is not so common. The areas from which the galls are sloughed is open to attack from other bacterial or fungus diseases.

The gall tissue is liable to spread in strands within the growing tissue of the plant and break out as secondary galls or tufts of root hairs on any part of the root, and secondary galls may also break out in the stem or branches or even leaves. In the main, however, the trouble is confined to the neighborhood of the roots.

The bacteria gain entrance to the root tissues from infected soil, mainly through wounds made when transplanting or cultivating or wounds made by the various root-infesting insects. The disease spreads rapidly through a patch of raspberry canes owing to the fact that during cultivation and thinning out the roots and runners are frequently cut or broken, thus enabling the bacteria to enter the tissue should the soil be infected.

The disease gets established in an orchard mainly through the planting of infected nursery stock. When planting out young trees, therefore, care should be taken not to plant any that show gall formation or hairy root. These should either be burned or returned to the nursery for exchange.

It is not much use to cut away a gall from an affected plant, as portions of the infection will almost invariably remain in the apparently healthy tissue adjoining the gall. If such an attempt is made, care should be taken to sterilize the knife or saw by wiping it with a solution of corrosive sublimate 1-1000, or some other disinfectant, before using it on any healthy plant.

How long the infection will remain in the soil after getting established there from infected stock has not been determined. It is recommended that at least two or three years be allowed to elapse after removing infected plants or trees before planting any varieties of plants that are liable to contract the disease.

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