CHAPTER XL

BACTERIA AND DISEASE

681. Dangers to life. — Man's health is often assailed by his inward appetites and desires. He is also exposed to accidents and dangers from without. Formerly men were in constant danger from wild animals, but now man — the noblest and most powerful living being — is constantly assailed and often conquered by the smallest and simplest of living creatures. In the midst of his work he may be stricken with a deadly disease because millions of tiny creatures are poisoning the cells of his body.

The microscope has revealed a world of tiny creatures of an infinite variety of form and manner of life. Three of the simplest forms are *yeast*, *mold*, and *bacteria*. All of them are of importance to man.

682. Yeast is a plant which consists of a single cell scarcely larger than a red blood cell. The cells live upon sugar, and begin a series of changes to return it to the air and water for use as plant food. Were it not for this provision, much plant food might encumber the earth in the form of sugar and starch, and both man and animals might starve. After the sugar upon which yeast cells feed is used up, they remain in a dormant state, and some become dried and pass off as dust. Some are always floating about in the air ready to grow in anything containing sugar. Yeast must have warmth and moisture for its growth. So cold or dried fruit does not sour. Yeast is

used in bread making and in the manufacture of alcohol (see Chapter IV).

683. Molds form a class of plants which may grow in nearly all kinds of moist substances, and there induce a kind of decay. They may usually be recognized by their furry growth on the surface of the affected substance.

Diagram of mold (× 200).

a ball of spores above the surface.
b threads beneath the surface.
c spores beneath the surface.

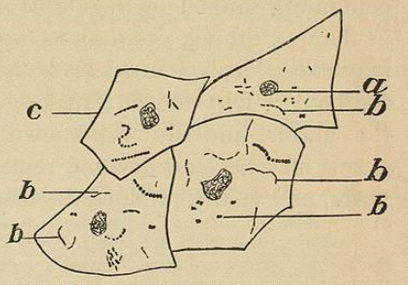
The plants themselves are usually a series of threads which burrow beneath the surface. At intervals they send up slender shoots which bear germ cells or *spores*. These shoots constitute the fur which is usually called mold, but many kinds form their spores beneath the surface. The spores are microscopic in size, and can float in the air and grow into mold plants when they fall upon a suitable soil. Most forms grow only on dead material, but a few can grow on living matter. The smut and rust on grain and fruit are plants similar to molds. Ringworm is due to a

mold which grows in the human skin. Mildew and toadstools belong to the same family as molds. In nature molds disintegrate, and return to the soil and air all kinds of dead plant and animal substances, especially hard and resisting tissues like bones, tree trunks, and skins, so that they can again become available as plant food. In warm, humid weather molds grow readily and are often destructive to food and clothing.

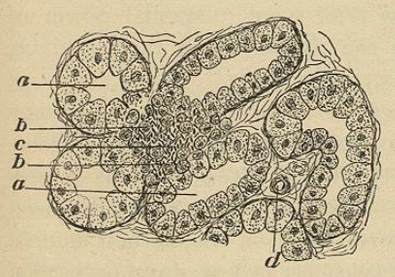
684. Bacteria. — The smallest and simplest, as well as the most numerous of living creatures, are round or rod-shaped bodies from $\frac{1}{25000}$ to $\frac{1}{10000}$ of an inch in breadth, and seldom more than $\frac{1}{1500}$ of an inch in length. They are sometimes called *microbes*, but more common names are *bacteria* or *germs*. They are all plants whose mode of growth somewhat resembles the yeasts and molds. Like yeast and mold they, or their spores, are scattered everywhere in the air. When they fall upon moist albumin they grow. A single one can produce over 10,000,000 in the course of twenty-four hours. They often resist influences which would destroy most other forms of life. Even boiling for five minutes fails to destroy the spores of some.

685. Effects of bacteria. — Bacteria destroy the substances in which they grow. Most forms of decay are due to the action of certain varieties of bacteria. They cause dead matter to become soft and melt away, usually with the production of foul-smelling gases and a variety of poisonous ptomaines. In the soil there are forms of bacteria which oxidize all kinds of animal and vegetable albumin as thoroughly as though it were burned. Thus bacteria destroy the dead and waste matter of vegetables and animals and prepare it for vegetable food again. Yeast, mold, and bacteria are indispensable friends of all living beings; and decay is a step in the preparation of our food.

686. Effects of bacteria upon living bodies. — Wherever there is a moist cavity containing albumin, bacteria may grow. The mouth is usually swarming with them, and may be offensive from the decay which they cause. They also grow abundantly in the intestine. A few forms can grow in the lymph spaces within a living body. Their poisons, circulating with the blood, may produce various diseases. Erysipelas, diphtheria, typhoid fever, consumption, cholera, lockjaw, and the grippe are all caused by living germs which enter the circulation from without. Because these diseases are always caused by an influence from outside they are said to be *infectious*.



Bacteria growing in the mouth (× 400).
The specimen was obtained by scraping a healthy mouth.
a nucleus of an epithelial cell.
b different forms of bacteria.
c outline of an epithelial cell.



Bacteria growing in a kidney and producing an abscess (× 300).
a kidney tube.
b white blood cell attacking bacteria.
c bacteria.
d blood tube of the kidney.

Measles, scarlet fever, mumps, whooping cough, and smallpox also are due to some influence from without the body. This influence is supposed to proceed from a kind of germ, also. These diseases can be caught by being in the same room with a sick person, and so are said to be *contagious*.

687. How bacteria enter the body. — Germs of an infectious disease can grow outside the body in a damp soil containing animal or vegetable matter. They may grow in damp clothing, or in sinks or wells, or in the soil, and may cause disease in whoever happens to take them into the body. Dirt and filth make good soil for the growth of the germs, and are well-known causes of disease. The germs may become dry and remain in a dormant state for years, and finally produce the disease again.

Bacteria may enter the body wherever the epithelium is gone, and the lymph spaces are bare. Even a scratch or a pin prick may admit thousands at one time. They can also enter through the mucous membrane of the nose or throat, or they may be swallowed in drinking water or licked off from a knife or spoon which another person has used.

688. How the body destroys bacteria. — Germs of disease constantly surround us, and the skin is constantly being scratched and pricked, affording them entrance. Yet only in rare instances do they grow and produce sickness, for the body has three very efficient weapons of defense.

First. *The white blood cells* have a special power of seeking out bacteria and the toxins which they produce, and of enveloping and destroying them.

Second. *The plasma of the blood and lymph*, by some chemical power, is able to destroy germs of disease.

Third. The serum of the blood often contains a substance called an *antitoxin*, which, while it may be a poison itself, also poisons the germs and so stops their action. When a disease has progressed for a few days or weeks, the antitoxin is formed in sufficient amount to poison the germs, and so the disease comes to an end.

If the toxins of diphtheria germs grown outside the body are injected into a horse, the plasma of its blood will contain the antitoxin of the disease. If its blood is drawn and allowed to clot, the clear serum will contain the antitoxin, and if injected into a man suffering with diphtheria, will tend to overcome the germs and to cure the disease.

Cows sometimes have a disease which seems to be a modified form of smallpox. By vaccination, the same disease can be transmitted to a man in whom it causes but slight inconvenience, but yet protects him against smallpox almost as thoroughly as an attack of the disease itself. Universal vaccination has destroyed the terrors of smallpox, so that from being one of the most common and deadly of diseases it is now one of the rarest.

689. Destruction of germs outside the body. — The *sun* is one of the most efficient agents in destroying bacteria of disease. It acts partly by drying the food upon which they live and partly by means of its own chemical power. An abundance of sunshine in a place renders it almost surely free from disease. In some hot and dry climates decay is almost unknown, for bodies become dried before the germs can grow. On the other hand, darkness, decay, and disease go together.

The *wind* drives away the germs. In the open air it is almost impossible to transmit disease. In closed rooms, germs which are given off from a diseased body may collect in great numbers, and in sick rooms may reënter the sick person and so prolong his sickness. *Running water* also removes the germs.

The soil destroys germs of disease. In it are special germs whose work is to oxidize all organic matter, including other kinds of germs. It also filters out the germs so that they can spread only a few feet, unless the ground is continuously soaked with germ-laden sewage.

690. Antiseptics. — Man uses three principal means to destroy disease germs which may threaten him. In the first place, he may wash them away with soap and water. He can thus get rid of most germs.

Secondly. A boiling heat applied for fifteen minutes will kill all kinds of germs. A substance freed from germs is said to be *sterilized.* Clothes and utensils used in a sick room can be made safe for future use by boiling. Before a surgical operation, the instruments and dressings are thoroughly sterilized by boiling.

Thirdly. A variety of chemical substances called *antiseptics* are poisonous to bacteria and destroy them almost at once. Carbolic acid added to from twenty to one hundred times its weight of water is very efficient in destroying germs which it can touch. Bichloride of mercury added to from one thousand to five thousand times as much water, is also very good, but it destroys iron or tin vessels. Chloride of lime is also much used.

Substances must come into intimate contact with germs in order to kill them. A little carbolic acid or other antiseptic may impart an odor to a room or overcome a smell, but to destroy the germs it must be applied in quantity directly to the germ.

Before a surgical operation the surgeon washes and sterilizes his hands, and covers his clothes with a sterilized gown. He carefully avoids touching any object which has not been sterilized either by heat or by chemicals. Before he operates he scrubs and sterilizes the field of operation just as he did his hands, and then surrounds it with sterilized towels. At the end of the operation he covers the wound with a dressing which has been sterilized by heat or chemicals. Then no germs can enter, and the largest wounds heal in a few days without pain or discharge. The safety of operations now as compared with those of twenty years ago lies in the discovery of how to exclude germs of disease.

691. Care of a sick room. — When a person is sick, every effort should be made to exclude germs of sickness. Fresh air and sunshine are always of the utmost importance in a sick room. It will always be better to run the risk of having the room a little cold than to have its air close.

In contagious and infectious diseases, air and sunlight are the chief means of destroying the germs.

Cleanliness should always be enforced in a sick room. The night clothes and bed linen should be changed as often as they are soiled. The whole body should be bathed daily, and the teeth and mouth cleansed.

Talking above all things disturbs a patient. Especially avoid all references to doleful cases of suffering like the patient's. Do not ask him if he will have this thing or that, but bring it to him without annoying him with the necessity of deciding for you. Do not argue with the patient, but kindly agree with him. Be good tempered and always thoughtful of his welfare.

In a contagious disease all visitors should be excluded from the room, and all furniture not absolutely necessary should be removed.

When the disease is at an end, the sick room should be thoroughly scrubbed with an antiseptic. It should be opened to the sunlight and air for several weeks before being used again. Everything possible in the room should be boiled or scrubbed. The patient should receive a thorough bath before leaving the sick room.

692. Blood poisoning. — Disease germs may grow upon any open wound, making it tender and causing it to run matter. In severe forms they cause a swelling of the surrounding parts, producing *erysipelas* or *blood poisoning*. All this can be prevented or overcome by applying clean or antiseptic dressings.

Milk, in summer time, forms a good soil in which germs from the air grow and form acids and other poisons. They produce stomach and intestinal disease in bottle-fed babies. Boiling the milk and bottles destroys the bacteria and prevents the disease.

Consumption or tuberculosis, is the germ disease most to be feared. Its germs will grow in any tissue of the body and there produce tiny nodules like pinheads. After a while these nodules break down and form abscesses. They are found most often in the lungs.

The disease spreads mainly by means of the germs given off from the mouth. Becoming dried, they float in the air. So all secretions from the mouth should be collected and destroyed.

693. Boards of health. — In every community the law establishes boards of health, whose duty it is to see that cases of contagious diseases are properly isolated; to see that no premises become

filthy, and that no diseases are brought into the country from foreign lands. Owing to the strictness and efficiency of these boards, contagious diseases are now as rare and harmless as they were once common and deadly.

SUMMARY

1. Yeast is composed of living plants which begin the work of returning sugar back to its original elements.
2. Mold is composed of tiny rodlike plants which grow through animal and vegetable tissues and destroy their albumin.
3. Bacteria are the smallest living beings. They cause decay and change albumin back to its elements in the air and soil.
4. Bacteria may produce virulent poisons.
5. A few kinds of bacteria grow in the body and there produce various forms of disease, some of which can be transmitted to other persons.
6. The body is protected against the bacteria of disease by the white blood cells, by the plasma, and by substances produced in the blood.
7. Outside of the body, sunlight, fresh air, running water, and the soil destroy disease germs.
8. Man destroys disease germs by washing them away, by boiling objects containing them, and by poisoning them with such substances as carbolic acid and bichloride of mercury.
9. Sunlight, fresh air, and cleanliness are essentials in every sick room, and especially in infectious diseases.
10. After an infectious disease, the room and all its contents should be scrubbed, and thoroughly aired for a month.
11. The law organizes boards of health to control infectious diseases and their causes.

DEMONSTRATIONS

170. Place a little yeast upon a microscope slide and examine it with a power of at least 200 diameters. Notice the oval cells from which smaller cells are budding.

171. Take a bit of mold from cheese or bread and examine it with a power of at least 200 diameters. Notice the strings of mold which appear like very small jointed rods. Notice the collections of round spores at the tops of the projecting stalks.

172. Place a little hay in a bottle of water and set it in the sun. After a few days, place a drop of the water upon a glass slide and examine it with a power of at least 400 diameters. Notice that numerous bodies of various sizes and shapes are swimming in the drop. These are the *animalculæ* which older books describe. Notice also the real bacteria which appear as the finest kinds of dots and short lines. Most of them are in constant motion. Only a few kinds of bacteria can be recognized by their appearance.

173. Prepare some gelatine as if for the table, and pour some while hot into a tightly covered dish which has been boiled. Take off the cover for a moment before the class, and, replacing it, set the dish aside for a few days. Then a few specks of mold or of scum will appear upon the surface, each showing where a germ has fallen from the air and multiplied to form the spot. Explain that bacteria are studied in laboratories in much the same way.

174. Have a druggist prepare a solution of carbolic acid 1 to 100, and of bichloride of mercury 1 to 1000. Show the class how they should be used in washing the hands and clothes. Also show the pure drugs, and warn the class against using them in this form. Show also chloride of lime and other common antiseptics.

REVIEW TOPICS

1. Describe yeast and give its uses in nature.
2. Describe mold and give its uses.
3. Describe bacteria and their relation to decay.
4. Give the uses of decay.
5. Show how bacteria can enter the body and how they produce sickness.

6. Show how bacteria are destroyed in the body by white blood cells and by the blood plasma.
7. Describe an *antitoxin* and tell how it is used in treating diphtheria.
8. Describe vaccination.
9. Show how bacteria are destroyed by sunlight; by the air; by running water; and by the soil.
10. Show how man destroys bacteria by cleanliness; by heat; and by antiseptics.
11. Show how a surgeon destroys germs before and after a surgical operation.
12. Give some hints about the care of a sick room; and about cleansing it after an infectious disease.
13. Describe the disease tuberculosis, or consumption.
14. Give the duties of a board of health.

NOTE. — For a more extended discussion of bacteria and disease, see "The Story of the Bacteria," by T. Mitchell Prudden, M.D.

CHAPTER XLI

REPAIR OF INJURIES

694. Injuries. — Many causes outside the body operate upon its cells to injure them. Excessive heat or cold may impair their vitality or cause their death. A sudden change from heat to cold is a common cause of injury. Blows and cuts may kill whole armies of cells. Above all, bacteria may cause injury and disease. In a few hours, the injured part shows a change, which is apparently due to an increase of the injury, but which is really caused by nature's attempt to repair the part.

695. Congestion. — After an injury has been received the first step in its repair is to dilate the arteries so as to permit more blood to flow through the part. Then more plasma will penetrate into the lymph spaces. This produces redness and some swelling and is called *congestion*. Congestion is a sign of attempted repair. This alone may be sufficient to heal the injured part.

696. Inflammation. — If the injury is greater, there is a change in the behavior of the white blood cells. Ordinarily they tend to flow more in the outer part of the blood stream, but when the arteries enlarge as a result of injury they adhere to the sides of the smallest blood tubes and some pass entirely through their walls and lodge in the lymph spaces. There they envelop and digest the injured parts and carry them away with the lymph. The lymph and blood cells have great power of absorbing blood and