THE HUMAN BODY AND ITS ENEMIES

A TEXTBOOK OF PHYSIOLOGY HYGIENE AND SANITATION

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WITH TWO HUNDRED AND FORTY-SEVEN ILLUSTRATIONS

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PREFACE

An examination of school physiologies published within the last four or five decades discloses the changing viewpoints of teachers of this subject. First anatomy was emphasized, then physiology became prominent, while in recent years, leaders in educational thought are agreed that hygiene is of paramount importance. Within this recent period there has been a shifting of accent from dress and diet to the prevention of germ diseases. The most generally accepted course of today, for elementary physiology, is one which does not minimize any of the phases of the subject, but preserves a correct proportion among them.

The essential principle of hygiene has ever been cleanliness. The race has developed an instinctive horror of the unclean. Since the discovery of microörganisms as the causative agents of disease, however, our adherence to cleanliness has become specific and intelligent. There are, for example, many harmless substances far more revolting than human blood containing malarial parasites. But modern hygiene teaches that the blood of a malarial patient, taken in conjunction with a certain species of mosquito, makes a combination which is, from a health standpoint, very unclean.

There is, therefore, a well-founded demand that children be taught the essentials of germ diseases and their prevention. The authors of the present volume have placed this material first, believing that its importance justifies this order of treatment.

In some quarters a certain timidity prevails in dealing with the topics of health and disease, on the ground that increased knowledge along these lines will lead to a more pessimistic point of view. The important rôle of optimism in the preservation of health is well recognized. Yet, in view of our present knowledge of the wonderful defenses of the human body, *it must be conceded that an understanding of them gives an increased confidence and renewed optimism based on fact and not merely on sentiment.*

The discussion of the anatomy of the human body has been in this book reduced to a minimum, and the physiology has been subordinated to the principles of hygiene. Such a treatment is believed to appeal to the reason of the child, for persuasion is more effective than arbitrary command.

The fact has been borne in mind that physiology and hygiene are practically the only natural sciences that the great bulk of our people ever have an opportunity of studying. The scientific treatment has, therefore, been adhered to as closely as the intellectual advancement of the pupil for whom this work is intended, would seem to allow.

Aids to the memory, however, have not been omitted. A summary of the important points together with carefully selected questions, at the end of each chapter, will be found of help to the pupil in his study. Frequent review questions and cross references in the text afford ample opportunities for repetition.

Experience in teaching science soon convinces one that poor thinking is largely due to vague mental concepts of things and relations. The laboratory method of seeing for one's self has been followed in these pages. The numerous experiments introduced throughout the book are all simple and can be performed easily with very little outlay for apparatus and material.

Illustrations are considered a necessity in a modern scientific book, particularly in one intended for the young. Many of the illustrations in this book were drawn expressly for it, and for most of them a distinct pedagogical value is claimed.

In adapting the work to present conditions in Texas, the authors have received valuable assistance from the State Medi-

cal Association, acting through its Textbook Committee; while the chapters on the care of the teeth were written with the coöperation and advice of the State Dental Association, acting through its Textbook Committee. The authors' grateful thanks and expressions of appreciation are due to them and to their many friends of the teaching and medical professions in Texas and other states, for kind assistance and suggestions in the preparation of the volume.

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CHAPTER I. INTRODUCTION

The rider of a motorcycle must study his machine. He must know its various parts, understand how they are put together, and have a clear idea of the work each part performs. Without knowing these things he cannot hope to keep the machine in good order or to feel the pleasure of its smooth motion.

The Human Body a Living Machine. It is the duty of each one of you to care for and operate a machine much

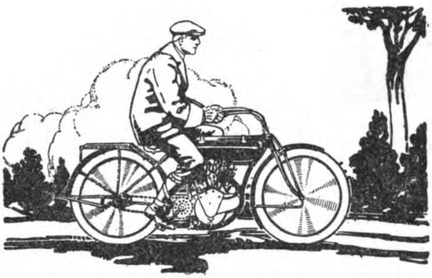


Figure 1. — The rider of a motorcycle should understand his machine.

more interesting than the motorcycle; namely, the human body. Did you ever stop to think what a wonderful machine your body is? Think of the brain, with which we know and remember things, feel emotions, and control our acts; and the eye, which is a little camera in itself. Think how wonderfully all the parts of our body are connected by the nerves, which act as telegraph wires, carrying messages from the various parts to the brain, which is like the central office.

The human body is certainly the most marvelous, the most delicately balanced and the most sensitive machine in existence, surpassing any invention of man, and if we are to operate it without doing it harm, we should certainly understand something about it, so that we may take proper care of it and see that this wonderful machine does its work as it should.

Dangers which Threaten the Body. The rider of a motorcycle, however, must know more than the parts of his machine; he must know also what kind of dangers are to be met in the road on which he is to travel. He must know the whereabouts of cactus thorns, sharp stones, and deep sands, in order to avoid them. Just so the driver of the human machine must know what dangers beset him on his life journey. The habit of drinking alcohol, for instance, is a danger that besets some of us. Impure foods are very harmful to the body, and they are one of the dangers that may befall any of us. One of the commonest dangers, however, that lurks along the pathway of all of us is disease or sickness due to germs.

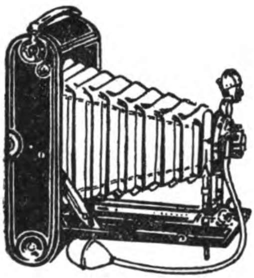


Figure 2. — A camera.

Disease Germs and the Body. Disease germs not only cause more than one third of all deaths that occur in the state, but also cause a large part of the blindness and other ills that afflict our citizens. And yet we cannot be

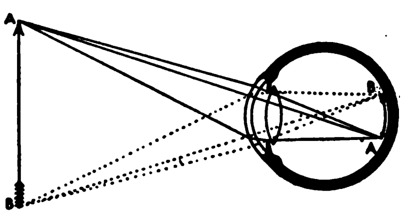


Figure 3. — The eye, a human camera.

harmed by disease germs unless they enter our system. In order, then, to protect ourselves against these enemies, we must study them and learn where they come from and how they gain entrance into the human body. We shall then be in a position to avoid them, and thus steer our human machine clear of this danger.

Figure 4. — A few of our germ enemies.

If we understand our bodies, and also understand just what dangers threaten them and how to avoid these dangers, we shall be more likely to succeed in keeping ourselves in that pleasant condition which we call *health*.

IMPORTANT POINTS

1. The human body is more complex than any machine or instrument made by man.

2. We should understand this machine in order to keep its various parts in order.

3. We should also know how best to avoid certain dangers which threaten us, such as typhoid fever, tuberculosis or consumption, and other diseases due to germs.

QUESTIONS

1. Why should we study the human body? 2. Name some things which can injure the body. 3. Name one important cause of blindness. 4. What proportion of all deaths in Texas is due to germs? 5. Name several things we should know about disease germs in order to avoid them.

CHAPTER II. BACTERIA OR GERMS

What are Bacteria? The word *bacteria* comes from a Greek word meaning little rods. Scientists reserve the word for those germs that are shaped like little rods, but in this book we shall use the word *bacteria* and the word *germs* as though they meant the same. Bacteria are such wonderful little beings, and they are so different from the creatures which you know, that it is very hard to get an idea of what they really are. All of you have read in the fairy tales about certain fairies that were invisible. The story of

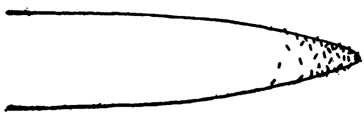
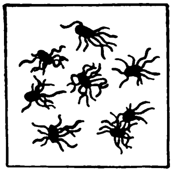


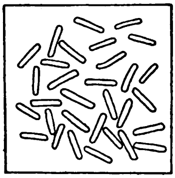
Figure 5. — This shows bacteria on the point of a needle, highly magnified.

bacteria is like a fairy tale, because for many centuries we were surrounded by bacteria, and yet they were invisible to us, and in fact we never guessed or dreamed that they existed until long after Columbus discovered America. And bacteria are invisible to this day, unless we use a microscope to aid the human eye, or unless we look at a great many of the bacteria in a clump or colony.

Size of Bacteria. To begin with, then, bacteria are very small. If you took a colony of them and picked it out with a needle till you had little pieces that you could barely see with the naked eye, each one of these little pieces would contain hundreds and probably thousands of bacteria. Many of them are so small that it would take twenty-five thousand of them placed side by side to occupy the space of an inch. As small as they are, however, each one has a definite shape. Bacteria are generally found in one of three different shapes, the ***rod-shaped***, the ***round-shaped***, and the ***spiral-shaped***. You can see examples of each of these in Figure 4.

Motion of Bacteria. Some bacteria can swim about from one place to another, and others never move unless they are washed about or jostled in the fluid they live in. Those that move, either do so by squirming along like a





Figures 6 and 7. — The rod-shaped germs cannot move about rapidly like the ones with the little lashes on them.

snake swimming, or else they have, growing out from their bodies, tiny hairs with which they whip the water. Of course the perfectly round ones cannot squirm, and unless they have little hairs on them, they cannot move.

Food of Bacteria. The bacterium (for this is the word we use in speaking of a single one) needs food, and it may even need oxygen just as we do. But it is so small that the food can soak in from the outside, and so it does not need a mouth. Practically all of its active life is spent in a liquid, and the food simply dissolves in the liquid and passes through its very thin skin into its inside. For you know the entire bacterium is not nearly so thick as a sheet of tissue paper, and its skin must be really so thin that we cannot realize its true thinness. But some bacteria (here we use the plural word again) seem to secrete a juice of some kind that digests meat. The difference between their digestion and ours, however, is that they pour the juice over the meat or other food while it is still outside

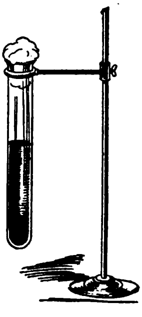


Figure 8.—Picture of a glass tube containing bacteria growing on gelatine.

their bodies. They let the digestion occur outside their bodies, and then absorb or soak up the food in a liquid form.

Toxins. Whatever of waste matter there is in the body of a bacterium can soak or ooze out, just as its food soaks in. This is one way that some bacteria injure us. Some kinds of bacteria live in our bodies and there pour or ooze out their waste material. If this waste material is poisonous to us, the bacteria make us sick. The poisonous material is called *toxin*, which means poison. Other bacteria form a waste material which is not poisonous, and these bacteria do not make us sick unless they multiply fast enough to stop up some passageway, such as a blood vessel, in the body.

Multiplication of Bacteria. Bacteria can multiply very rapidly indeed. They seem to multiply by simply dividing in two. Each one thus divides, and you have two bacteria where only one was in the first place. Starting with one bacterium, we may have many millions in a day or two.

Ultra-microscopic Bacteria. In studying bacteria we must not lose sight of the fact that some are too small to be seen even with the most powerful microscope. No one has ever seen these germs. You may well ask how, then, we know that they exist. We know only from their effects. For instance, we know that foot and mouth disease in cattle is caused by a germ, and the blood of an animal sick of this disease, if injected into another animal, will cause the second animal to catch the disease. Even if we filter the blood from the sick animal, so as to remove all particles large enough for us to see with the most powerful microscope, it will still cause foot and mouth disease when injected into another animal. Our filters are fine enough to strain out all germs that are visible, and since the filtered blood still causes disease, we must conclude that it contains invisible germs. These germs are so small that they pass easily through the filter and set up foot and mouth disease as soon as they reach their natural living place, which is the body of the cow. Possibly some pupil, at present busy in one of our schools, may some day invent a microscope powerful enough to reveal these ultra-microscopic bacteria to our sight. The word *ultra* means beyond, and these bacteria are called ultra-microscopic because they are beyond the power of the microscope.

Smallpox, yellow fever, measles, and infantile paralysis may be due to small bacteria which we call ultra-microscopic. Certain diseases which attack the lower animals have been proved beyond a doubt to be due to ultra-microscopic germs.

Where Bacteria Live. We have said nothing yet about where the bacteria live. They live almost everywhere, — in water, in milk, in the ground, in dust, in decaying fruits, — almost everywhere except where they have been removed in some way. The most important place that bacteria inhabit is certain parts of our bodies. Some harmless bacteria are always present in the mouth. There are always a great many harmless bacteria in the intestines and in the outer horny layer of the skin. Certain kinds cause milk to sour. Certain others cause milk to curdle into cheese. Still other bacteria live on the roots of clover and peas and help to enrich the soil.

Harmless Germs and Disease Germs. There are thousands of different kinds of germs or bacteria, and probably not over one hundred different kinds that are harmful to man. There are some that do not multiply anywhere except in the human body, and there make poisons causing sickness or death. These bacteria are dangerous. Typhoid fever, meningitis, tuberculosis, grip, and diphtheria are all caused by bacteria. These germs are visible with the microscope, but are so small that they could not harm us except for the poisons which they make in our bodies.

Disease Germs Multiply Only in the Body. It is very important to remember that very few of the bacteria which cause disease can live more than a few weeks or months outside the human body. These harmful bacteria do not as a rule multiply at all except in the human body. It is therefore much easier to keep free from them, because all we have to do is to see that none of the bacteria from sick people enter the body. Think how hard it would be to avoid typhoid fever, for instance, if the germs were found naturally in the ground. It is hard enough to keep free from them when we know that they exist only where they have been thrown.

How Bacteria are Scattered. The germs seem to have great success in getting themselves scattered. Diphtheria germs can be carried from one individual to another on such a little thing as the point of a pencil, especially if the users of the pencil place it in their mouths. Waving a soiled handkerchief in the air may set the germs floating in the air, and they may be taken into the body with the breath. The fingers which have touched such a handkerchief may grasp a door knob and leave many germs there. The next fingers that grasp the door knob will take away some of the germs. The washerwoman by handling the soiled linen is especially likely to get the germs into her system. *Every solid or liquid particle that leaves the body of any one suffering from a germ disease may carry the germs of that disease.* Whether it be saliva, tears, perspiration, bath water, or any other thing of this kind, it is dangerous, because it may have germs in it.

Careless People. Since we now know the exact germ that causes each one of the diseases mentioned, and since we know just how the germs are carried from one person to another, it is only a question of time until we shall get the diseases under control. This knowledge is so new that the majority of people either do not possess it or cannot realize the truth about it. You will see men and women with sweet character who nevertheless go about spreading disease germs and causing sickness and death. Have you not seen consumptives spit on the floor? It would be kinder if the consumptive would set a steel trap to catch little children by the foot, instead of setting this disease trap for them. Boys and girls in school now should learn a great deal more about disease germs than their parents could when they were in school. The spitting nuisance is dying out. People sometimes need to expectorate, but they should expectorate into the toilet, or into a cuspidor or spittoon containing water or else something that will kill the germs. It is also permissible to expectorate into rags or paper napkins which can be promptly burned.

IMPORTANT POINTS

1. Bacteria are too small to be seen with the naked eye, and some of them are so small that we have never even seen them with the microscope.

2. Bacteria live almost everywhere, especially in decaying food and dirty places.

3. Many bacteria live in our bodies, and a few are harmful to us. Most of the harmful ones produce toxins which make us sick.

4. Many people have never learned the importance of not spitting on the floor.

5. The pocket handkerchief becomes dangerous as soon as it has been soiled, and it becomes soiled as soon as it has been used.

QUESTIONS

1. How small are bacteria? 2. Can they all move about? 3. How do bacteria multiply? 4. Name some places where bacteria live. 5. Are all bacteria harmful to man? 6. How do they injure us? 7. Name some of the ways in which disease germs are carried from one person to another. 8. What should persons suffering from any communicable disease use, instead of the ordinary pocket handkerchief?

CHAPTER III. DISEASES THAT ARE CATCHING

Did you ever have measles or mumps? If so, you may be able to tell just from whom you caught the disease. In other words, you could trace the source of contagion or infection. Some diseases, like measles and smallpox, are understood to be contagious, or catching. A better word to use is *communicable*. A communicable disease is one that can be communicated or given to another.

Communicable Diseases. There are a great many diseases that are communicable; for instance, typhoid fever. We have always known that leprosy, cholera, smallpox, plague, measles, scarlet fever, hydrophobia, diphtheria, and others were communicable; but we have learned only in our own generation that consumption, typhoid fever, malarial chills and fever, yellow fever, meningitis, infantile paralysis, erysipelas, and dengue are also communicable. A great many well-informed and educated people today do not realize this fact.

Scientists who Gave up their Lives. Many scientists have given up their lives in the effort to find exactly how communicable diseases are spread. In 1900, Dr. Lazear and Dr. Carroll, both United States Army surgeons, willingly contracted yellow fever in order to find the exact method by which it is spread. Dr. Lazear died after a few days; Dr. Carroll lived for several years, but finally died as a result of the yellow fever. Dr. Ricketts, a young physician of Chicago, went to Mexico in 1909 to study jail fever. During his experience he was attacked by the disease and died.

How Diseases are Communicated. By exposing themselves to danger these scientists have found out just how most of the communicable diseases are spread. These diseases are not all spread in the same way, although all of them are conveyed by solid or fluid particles which leave our bodies. Water spreads disease only when the particles of solid or liquid material that leave our bodies are in the water. Even the mosquito cannot carry disease except

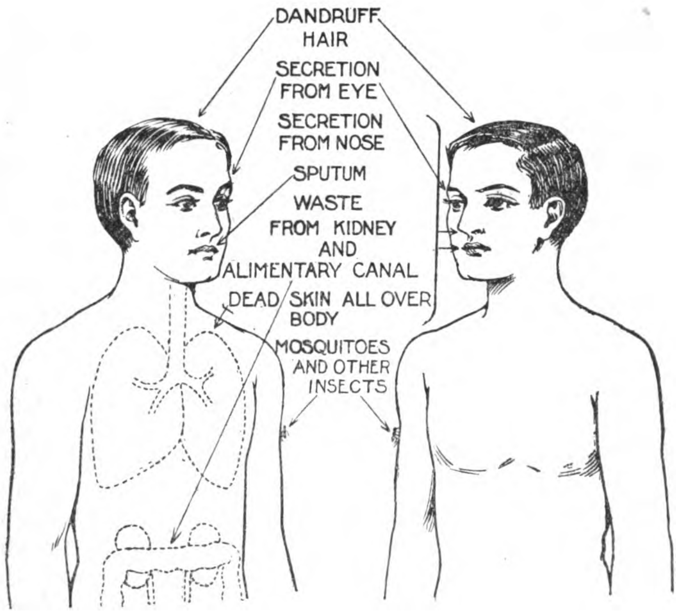


Figure 9. — This picture shows almost all the different ways by which germs or contagion can leave or enter the body. There is not one solid or liquid particle cast off from the human body which may not, under certain conditions, carry or convey disease. Beginning at the top, you will note that dandruff is cast off from the scalp. Dandruff is in all probability a contagious disease spread largely by combs and brushes in barber shops. Pus from the eye conveys sore eyes of several kinds, some of which can cause blindness. Secretion from the nose and mouth is the medium for spreading consumption, diphtheria, tonsillitis, acute rheumatism, certain forms of meningitis and other diseases. Dead skin from the surface of the body is believed to spread smallpox, scarlet fever, measles, and other diseases. Waste matter from the kidneys and bowels undoubtedly conveys typhoid fever, dysentery, Asiatic cholera, hookworm disease, and others. The mosquito is the only insect pictured here, but many other insects carry disease from one person to another. You will learn more about these in Chapter XV. From this page, learn one lesson: *All contagion is due to solid or liquid particles which leave the body of the sick, while absolutely all such particles are capable of carrying disease.*

when it has sucked some of the blood of a person who is ill. The fly is powerless to carry disease except when it has been walking over some of the waste that is cast off from our bodies. The air spreads disease germs only by means of the small particles of dry or liquid material which leave the body of a sick person and float in the air.

The Dangers of the Pocket Handkerchief. The clean handkerchief can serve a good purpose, but as soon as a handkerchief has been used to remove secretion from the nose or mouth, it becomes a source of danger. The handkerchief is really a dangerous article, for it may be carried in the pocket long after it has become soiled with disease germs.

Such an unclean handkerchief may be flirted in the air so as to distribute its germs; it may also scatter the germs over the face and hands; and it may carry disease germs into the pocket, where they may soil the hands or soil other articles in the pocket. It would be much safer to use paper napkins, which can be destroyed after they have once been used. Invalids and sick persons generally should by all means use paper napkins or cloths that can be burned, and should carry a waxed paper or oil cloth wallet to contain the soiled napkins or cloths until they can be burned. Those who use handkerchiefs should have a new or clean handkerchief at least once daily when in health, and oftener when the nose is giving off secretion.

How Disease Germs Leave the Body. Try to rid your mind of that old, hazy, indefinite idea that contagion may be in the air, or due to bad weather or an unhealthful climate. Instead, think of contagion as something definite, that you can see and weigh and feel. Let us take note of the different ways in which particles leave the body. We have first the waste materials, which are thrown off by the kidneys, the alimentary canal, and the skin. Then we have the dried skin, which peels off from every part of the body; these little particles are believed in some cases to carry the germ of smallpox. The hair may spread a very troublesome disease of the scalp called ringworm. Then there are the sputum and saliva from the mouth, and the nasal secretion, both of which may spread many different diseases, such as measles, scarlet fever, diphtheria, consumption, meningitis, leprosy, and smallpox. The secretion from the eye is responsible for the spread of trachoma or granulated lids, and conjunctivitis or sore eyes. All the discharges mentioned leave the body naturally. In addition, certain insects take from the body blood, which may convey malaria. There are, then, many different ways by which solid and liquid particles leave our bodies, and some kind of disease germ may be carried by almost every one of these particles. To get a clear idea of how communicable diseases are spread, let us take certain examples.

Typhoid Fever. Typhoid fever is spread especially by the body wastes, which are thrown out from the sick room on the ground. Flies light upon the wastes, dip their feet in them, and may fly into the dining room and walk over our food. Then, too, the rain may wash these body wastes into the well or spring, and we may drink the water containing the typhoid germs.

Tuberculosis. This disease is spread especially by dust from dried sputum, or spittle. For instance, a consumptive spits on the floor; the sputum dries; and when the floor is swept, the dried sputum is thrown up in the air with the dust and is inhaled by all the persons in the room.

Malaria, Yellow Fever and Dengue. Malaria, yellow fever, and dengue are not spread by body wastes, but by the mosquito which gets a drop of blood from a patient suffering from the disease and then bites a well man; and thus the malaria or other germs are injected into the well man.

Diphtheria. A person suffering from diphtheria may soil the handkerchief with secretion from his nose. In handling the handkerchief, the secretion and germs get on his fingers. He then handles knife and fork, and door knobs, or shakes hands with some one. The germs are thus passed on to the hands of others, who in turn pick their noses or use a pocket handkerchief, and thus place the germs in the nose. From the nose they easily get into the throat and cause disease.

Granulated Lids or Sore Eyes. These diseases are spread by the secretion from diseased eyes. The secretion, or pus, is collected on a handkerchief, and some of it reaches the fingers. From the fingers it contaminates pencils, towels, door knobs, etc.

Every person sick with a communicable disease has been given the disease by some secretion or excretion from the body of another person who has the same disease, and the newly sick person may communicate the disease to others.

IMPORTANT POINTS

1. All disease germs are carried from the body by some solid or liquid particles thrown off from the body.
2. Sputum and body wastes are especially likely to contain disease germs.
3. No disease can spread if we prevent the solid and liquid particles which leave the patient from getting into or on some other person.

QUESTIONS

1. Name all the solid and liquid particles which leave the body. (For example, body wastes, perspiration, etc.) 2. What is meant by communicable diseases? 3. Name ten communicable diseases. 4. Name three diseases spread by sputum. 5. Describe how disease germs from body wastes can get from the ground into a new patient. 6. Name some careless habit by which disease is spread by sick people.

CHAPTER IV. OUR PROTECTION AGAINST DISEASE GERMS

From previous chapters you have learned something of the enemies which attack our bodies from without, and it now remains for us to learn how wonderfully we are protected against these germ enemies. Let us not think for one instant that the germs have an easy fight even after they get into our bodies. Before any germs can cause disease, they must fight the battle of their life, and the human body wins out in the vast majority of cases, for it has a wonderful system of defenses against disease germs.

The Skin as a Protective Covering. To begin with, our skin has on the outside a thin horny layer, which few bacteria can penetrate, if it is kept healthy and whole. The best way to keep the skin healthy is to keep it clean with soap and water. People who take a bath every day are more likely to avoid disease than those who bathe less frequently. Persons who take less than one bath a week are dirty. People ought to take at least two or three baths a week, and one of them should be a warm bath. In addition the face, neck, and hands should be washed when we think they are soiled. We should wash our hands when we have been to the toilet, and whenever we have been in contact with the sources of contagion of which we are learning.

Figure 10. — The skin, showing its protective horny layer.

Figure 11. — The gastric juice in the stomach is fatal to most germs.

How the Gastric Juice Kills Germs. The stomach, too, is well protected. It is the first stopping place of everything we swallow. The stomach always contains some gastric juice, which is the digestive fluid formed by the stomach. It is fatal to germs, because of the strong acid, called *hydrochloric acid*, which it contains. Gastric juice also contains a substance called *pepsin*, which will digest germs; hence if our digestion is good, not many germs will pass through the stomach.

White Blood Cells. Whenever germs get into the body, as for instance when a wound is washed with unboiled water, they are almost immediately attacked by the white cells of the blood. On later pages you will learn that the blood contains many little round bodies, soft like jelly. Most of them are red, but some are colorless. The colorless ones are called the white cells of the blood, and they

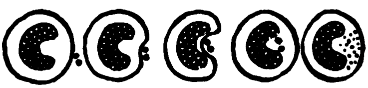


Figure 12. — White cell of the blood swallowing and digesting germs.

take up or swallow germs, as shown in Figure 3. These white cells might be compared to policemen, as they capture the germ enemies that have invaded the body. Sometimes the white cells digest the germs, but sometimes the germs kill the white cells. When a person is in good health, however, his white cells can usually destroy the few germs which get into the body.

Immunity, Another Protection against Germs. It is generally true that after a person has recovered from an attack of measles, he cannot be affected by this disease again. The body has become changed in some way. It is hard to understand just how the body undergoes this change, but we can easily see that during the course of the illness, the body gains a protective power which it did not have in the beginning. A person who is protected against measles in this way is said to possess an *immunity* toward measles. Immunity, then, means the power to resist a particular kind of disease germ. A person may, however, possess a complete immunity toward measles without possessing any immunity toward other contagious diseases, such as whooping cough or scarlet fever. Measles is not the only disease that is followed by immunity. Smallpox is followed by immunity toward smallpox; scarlet fever is followed by immunity toward scarlet fever. A number of other contagious diseases are followed by immunity. An attack of one disease, however, does not cause a person to become immune to any other disease.

Changes in the Blood. The blood of persons recovering from typhoid fever has the power to injure or kill the typhoid germ. This can be seen by mixing a drop of the blood with a few drops of water and placing a number of typhoid germs in the mixture. If observed through the microscope, the germs are seen to lose their active motions and to lie still in groups or clusters. Blood from persons who have never had typhoid fever does not thus injure typhoid germs. We can therefore understand, at least in part, how immunity is produced. When germs produce disease by multiplying in the body, certain protective substances are formed and under certain favorable conditions can be found in the blood. The blood of persons recovering from some other germ diseases, produces a similar effect upon the particular germs concerned. This experiment shows that the substances which protect us against certain diseases are found in the blood.

Artificial Immunity. After you grasp the fact that the power to resist diseases depends in certain instances on protective substances formed in the blood, you will see how helpful it would be to cause the body to form these protective substances when desired. This can be done. Scientists have discovered that killed germs injected under the skin may cause the body to make these protective substances. If typhoid germs are killed by heat and injected properly, they cause a person's blood to become partly filled with substances which protect against typhoid. If living typhoid germs are added to a drop of blood from such a person, the germs are injured or killed just as if the blood were taken from a person recovering from typhoid. It is thus seen that the injection of killed typhoid germs causes immunity toward typhoid fever.

Explanation of Immunity. When disease germs of any kind multiply in the body, or when killed disease germs of any kind are injected into the body, the body usually makes substances which are injurious or fatal to that particular kind of germ. These substances are injurious to germs, and therefore protective to the body. Such protective substances are probably not actually made in the blood itself, but they soon pass into the blood and travel all over the entire body, thus protecting the body.

Kinds of Immunity. When we possess immunity by reason of having suffered an attack of the actual disease, we call it an *actual immunity*. When we possess immunity due to our having received injections of killed germs, we call it an *artificial immunity*. Artificial immunity can be produced by the injection of killed germs, and also by the injection of weakened germs. The germs, when killed, are usually killed by heat; if weakened germs are used they are weakened in various ways, — by heating, by chilling, by drying, by allowing them to live and multiply in the body of certain animals, and in other ways.

Artificial Immunity against Smallpox. The most important effect of artificial immunity is the prevention of smallpox. To produce immunity against this disease, physicians inject smallpox germs that have been weakened in a peculiar way; that is, by living in the bodies of cattle. Whenever smallpox germs live and multiply in the body of a cow, they become weakened and cause a very mild disease called *cowpox*. Germs taken from the cow and injected into persons do not cause smallpox, but cause a slight inconvenience, resulting in artificial immunity against smallpox. The weakened germs are called *vaccine*, from a Latin word meaning cowpox. To apply or inject these weakened germs is to *vaccinate*. Nearly all who study this book already possess an artificial immunity against smallpox because they have been vaccinated.

Vaccines. Vaccine had been used to produce an artificial immunity against smallpox for over half a century before artificial immunity was produced against any other disease. Today there are a number of diseases against which we can produce an artificial immunity, and we have come to use the word vaccine to refer to the various killed or weakened germs used for this purpose. A vaccine, then, is a preparation of killed or weakened germs used to produce artificial immunity.

Another Way to Produce Artificial Immunity. To *immunize* a person against any disease is to cause him to become immune to that disease. Scientists have found in certain instances that it is possible to immunize a horse against a disease and then take a part of his blood for immunizing persons. When this method is used to immunize persons against diphtheria, a horse is caused to receive injections of diphtheria toxin or poison until his blood becomes charged with protective substances. In this instance the protective substances are called *antitoxin*, meaning against or opposed to toxin. The blood of the horse is then removed in a very cleanly way (See Fig. 13), and is allowed to clot. The clear, straw-colored fluid that is formed when the clot separates is called *serum*. If this serum, containing the antitoxin, is injected into persons, it immunizes them against diphtheria.

Difference between Antitoxin and Vaccine. Whenever a vaccine or preparation containing killed or weakened germs is injected into a person, it usually takes one to three weeks for the protective substances to be formed. If the vaccine is injected after the person is actually ill from the disease, the protective substances are not usually formed in time to do any good. For this reason the vaccines are found more useful to prevent disease than to cure it. The protective substances in serum, however, are already made, and the injection of such serum often produces almost immediately a complete cure of diphtheria.

Artificial Immunity against Different Diseases. We have in artificial immunity a safe and efficient method of preventing smallpox, hydrophobia, Asiatic cholera, bubonic plague, typhoid fever, diphtheria, tetanus or lockjaw, and meningitis. Vaccines and serums for the treatment of other diseases are still imperfect, but are being improved. The practical value of artificial immunity will be discussed in the following chapter.

IMPORTANT POINTS

1. The skin acts as a barrier to keep disease germs out of the body.
2. Germs that are swallowed are usually killed and digested in the stomach by the gastric juice.
3. Germs that get into the body are usually attacked by the white cells of the blood.
4. When germs multiply in the body, they cause the formation of protective substances which circulate in the blood.
5. The presence of the protective substances in the blood of immune persons can be shown by placing disease germs in a drop of blood: the disease germs are injured or killed.
6. By the injection of vaccines, we can cause the formation of these protective substances.
7. Immunity is the power of the body to resist a particular disease.
8. Actual immunity is the immunity that follows an attack of a particular disease.
9. Artificial immunity is the immunity which follows the injection of vaccines or serums.

QUESTIONS

1. How does the skin protect the body? 2. How does the stomach protect the body? 3. How do the white cells of the blood protect the body? 4. What is immunity? 5. Name two kinds of immunity and tell the difference between them. 6. How can we prove that the blood of immune persons contains protective sub-

stances? 7. How can we cause the body to form protective substances? 8. How may the germs be weakened for preparing vaccines? 9. Describe the method of preparing diphtheria antitoxin. 10. Explain the difference in the effect of vaccines and serums (antitoxins). 11. Name all the diseases against which we can produce an artificial immunity. 12. Need the careful and cleanly person be alarmed on account of disease germs?

CHAPTER V. PRACTICAL VALUE OF ARTIFICIAL IMMUNITY

It would be fortunate indeed if we could immunize persons against all the communicable diseases as described in the preceding chapter. Only a few diseases, however, can be prevented in this way, and a list of them was given at the end of the last chapter. The present chapter deals with the need of artificial immunity and its value in each of these diseases.

Vaccination against Smallpox. The value of smallpox vaccination was recognized and proved about 1797 by an English physician named Edward Jenner. He found his vaccine ready-made, for the germs of smallpox are weakened by living in the bodies of cattle. Jenner's method, which is still in use, was to place some of these weakened germs in or under the skin of persons, and thus cause immunity against smallpox. Vaccination against smallpox is practically harmless, but it should be done in the most cleanly manner.

Importance and Need of Vaccination. The importance and need of preventing a disease depend upon two things: first, whether the disease is dangerous, and second, whether it is easily communicated or carried from one person to another. Smallpox is a dangerous disease, and kills from twenty to sixty per cent of those whom it attacks. It is also extremely contagious. From fifty to ninety per cent of all unvaccinated persons who are exposed to the disease are affected by it. Persons just becoming ill from smallpox can convey the disease to others before the dangerous character of this illness can be recognized. When we add the fact that the germ of smallpox can live for months in clothing and on furniture, we see that without vaccination it would be practically impossible to control this disease. Hence vaccination against smallpox is of great importance and value.

Effectiveness of Vaccination against Smallpox. Vaccination against smallpox practically always prevents the disease for several years. Afterward the protective power is gradually lost. Ninety-eight persons had the disease in a Texas city. Of these, only two had been vaccinated — one fifteen years before, the other sixty years before — and both recovered. In May, 1904, the United States Army ship *Liscom* left Manila with two hundred and ninety-two persons on board. During the first week at sea an unvaccinated child became ill with smallpox. Every one on board except three persons had been vaccinated. Within fourteen days all three of these persons developed smallpox, while not a single one of the two hundred and eighty-nine vaccinated ones took the disease. The medical officers of the United States Government strongly recommend vaccination, because they know it is the only safe and efficient way to prevent smallpox.

Vaccination after Exposure. If you are exposed to smallpox and are vaccinated at once, the vaccination will develop in time to prevent the disease. This is due to the fact that vaccination develops more rapidly than smallpox. It is believed that smallpox enters the body through the nose, and it takes a few days for the germs to multiply and pass on into the blood, skin, and other organs. In vaccination, the germs are placed in the skin, so that they multiply more rapidly, thus heading off the smallpox.

Our Duty to be Vaccinated. We not only owe it to ourselves to be vaccinated for our own protection, but we also owe it to our fellow-citizens to be vaccinated, in order to protect them. In no other way can we affect our neighbors more than by our own health; if we take a communicable disease, we are very likely to cause some one else to take it.

When and How Often to Vaccinate. Every child should be vaccinated before beginning to go to school. If this vaccination does not take, it gives no protection and should be repeated until it does take. After one good scar has been formed, there will be complete immunity for several years and partial immunity all through life. It is well to vaccinate again about ten years after the first vaccination, and if this takes, the immunity is generally complete for life.

Pasteur Treatment of Hydrophobia. Hydrophobia is caused by germs introduced into the body by the bite of a mad or rabid animal. The word *hydrophobia* comes from two Greek words meaning fear of water. Persons suffering from this disease are thrown into spasms by the attempt to swallow any fluid or solid substance, and it was formerly believed that they were afraid of water: hence the name hydrophobia. Animals that have become mad are said to be rabid; the disease is sometimes called *rabies*, from a Latin word meaning madness. Hydrophobia, when it occurs, always follows the bite of a rabid animal. The bite of the animal is therefore a warning that hydrophobia may develop. By prompt action, the disease may be headed off, for there is a way of immunizing against this disease. The method employed was discovered by the famous French scientist, named Louis Pasteur.

Today the Pasteur Institutes in Texas, at Austin and at El Paso, use the method that Pasteur worked out for protecting human beings against hydrophobia. At these institutes, the germs of hydrophobia are allowed to grow in the spinal cord of rabbits. These spinal cords, containing the hydrophobia germs, are removed in a very cleanly manner, placed in dry jars, and kept in a refrigerator until the germs lose their power to cause hydrophobia. This takes about fourteen days. Small pieces of these spinal cords are injected into persons who have been bitten by mad dogs or other animals believed to have hydrophobia. These persons become immune toward hydrophobia within three to five weeks, and unless they have been so badly bitten that they develop the disease within this length of time, they almost invariably escape.

The following animals are capable of having hydrophobia: dogs, cats, wolves, skunks, rats, mice, rabbits, horses, mules, cattle, goats, chickens, geese, and others. The first four mentioned are the cause of nearly all hydrophobia in Texas. When a person is bitten by an animal believed to be rabid, the animal should by all means be watched long enough to see if it is healthy. If the animal dies or is killed, its head should be removed, packed in ice, and shipped by express or parcel post to the nearest Pasteur Institute for examination. If the examination proves that the animal was rabid, no time should be lost in giving the bitten person the Pasteur treatment for preventing hydrophobia.

All hydrophobia due to the bites of dogs could be prevented by the muzzling of dogs.

Artificial Immunity against Typhoid Fever. Typhoid fever is common in Texas, as in other agricultural states, but it can be prevented by the injection of killed typhoid germs. The injection of these germs does not usually cause very much inconvenience. It takes about three weeks for the body to form the protective substances in the blood. A remarkable example of the value of artificial immunity against typhoid was shown by the experience of the United States Army at San Antonio in 1911. Many thousands of soldiers were encamped in San Antonio for several months during the summer season. Most of the soldiers had been injected with dead typhoid germs, and were immune. Not one single soldier that had been thus treated developed typhoid fever. Physicians and trained nurses often protect themselves against the disease by the injection of killed typhoid germs. Epidemics of typhoid fever in certain communities have been stopped by immunizing all persons under forty-five years of age in these communities. The killed typhoid germs have usually been furnished by the Public Health Series at Washington or by the Texas State Board of Health at Austin.

Asiatic Cholera and Bubonic Plague. Artificial immunity against each of these diseases can be produced by injecting a vaccine containing the killed cholera germs or plague germs. Cholera and bubonic plague are described on later pages.

Diphtheria Antitoxin. It takes three weeks to immunize a person against smallpox, hydrophobia, or typhoid fever. It takes only a day, however, to immunize a person against diphtheria, because the protective substances have been prepared beforehand in the blood of the horse. Hence diphtheria antitoxin will almost always cause an immediate improvement in the condition of a person suffering from diphtheria. Diphtheria antitoxin, therefore, is of value not only as a preventive, but also as a cure, of diphtheria. Children who have unquestionably been exposed to diphtheria should be immunized by receiving an injection of diphtheria antitoxin.

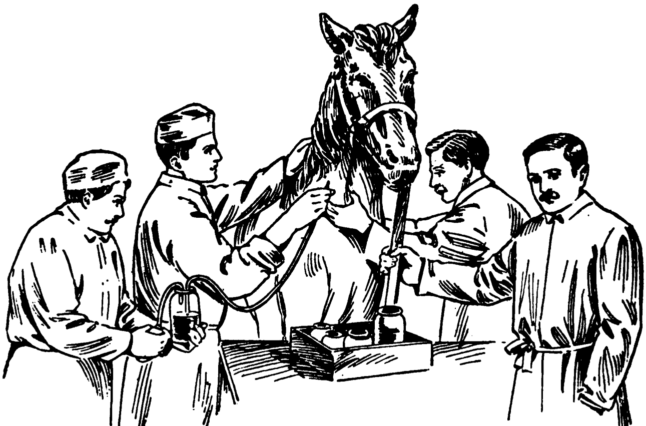


Figure 13. — Injecting the horse with diphtheria toxin in order to form diphtheria antitoxin in his blood.

Immunizing against Diphtheria. In the United States, the annual number of cases of diphtheria has not diminished since the discovery of diphtheria antitoxin, because *antitoxin has not been used often enough for immunizing those exposed to the disease.* The percentage of deaths, however, among persons suffering from diphtheria has decreased to about one fourth or one fifth of what it was formerly, because antitoxin is nearly always used to cure the disease. It is safer to prevent it than to cure it. Antitoxin should never be injected except under the supervision of a physician, especially if the person to receive it has ever had asthma or has ever received any kind of horse serum before.

Tetanus Antitoxin. Tetanus or lockjaw is a disease caused by germs introduced into a small, deep wound such as a nail thrust. Other facts about the disease will be mentioned later. Tetanus can be prevented by the use of horse serum containing tetanus antitoxin, but the serum must be used before the disease develops. After tetanus once develops, and the dreadful spasms begin, the serum does much less good. Tetanus is always the result of a wound of some kind, and hence persons have warning. Every nail puncture should be treated thoroughly, and in doubtful cases tetanus antitoxin should be administered.

Meningitis Serum. Meningitis is the dreadful disease described in Chapter IX. The serum from horses that have been immunized against this disease is the best known remedy for curing it. The disease rarely attacks more than one per cent of the inhabitants of a community, and for this reason it is extremely difficult to collect evidence as to the possibility of immunizing against the disease.

IMPORTANT POINTS

1. Vaccination against smallpox is the oldest as well as the most important method that we know of producing artificial immunity.
2. Vaccination against smallpox is safe and effective.
3. Smallpox cannot be controlled without vaccination.

4. Vaccination should be repeated after seven to ten years.

5. Vaccination after exposure to smallpox prevents the development of the disease.

6. It is a public duty of every citizen to be vaccinated.

7. Hydrophobia can be prevented by the Pasteur treatment, which should be administered promptly.

8. Typhoid fever can be prevented by the use of killed typhoid germs.

9. Diphtheria antitoxin cures diphtheria.

10. Diphtheria antitoxin should also be used as a preventive.

11. Tetanus or lockjaw can always be prevented by the prompt use of tetanus antitoxin.

QUESTIONS

1. Why is it so hard to prevent the spread of smallpox? 2. Who discovered the first method of producing artificial immunity, and where did he get the vaccine? 3. How often should the average citizen be vaccinated? 4. Explain why it is a duty to be vaccinated. 5. Give two ways of finding out whether a dog is mad. 6. Where in Texas are Pasteur Institutes located? 7. Which is more important, the cure or the prevention of diphtheria? 8. What kind of wounds cause tetanus? 9. How can tetanus be prevented?

CHAPTER VI. TYPHOID FEVER

Typhoid fever is somewhat like measles. It causes a breaking out or rose rash, like the rash seen in measles, although there are generally only one or two dozen spots on the skin at one time. It is like measles in that each typhoid patient catches the disease from a previous typhoid patient. It is like measles in that it seems to affect young people especially; old people are less often affected. It is important to remember that each typhoid patient must be carefully handled to avoid giving the fever to some one else.

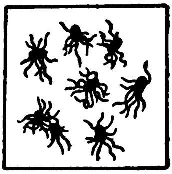


Figure 14. — Typhoid bacteria, showing the little lashes by which they move.

Importance of Typhoid Fever. *Typhoid fever is a disease that is very common in nearly all parts of Texas. It is common in town and city. Every year there are about nine hundred deaths from typhoid fever reported in our state; and yet it is a disease that can be prevented more easily than most other diseases. We can do more in preventing sickness and death by studying typhoid fever and its prevention, than in any other way. Typhoid fever is a contagious disease; see Rule 3, Sanitary Code.*

Germs of Typhoid Fever. Now, typhoid fever is due to a germ. The germ is a little rod-shaped bacterium that lives in certain parts of the intestines. It also lives in the blood and travels over every part of the body. It injures the entire body, but is especially harmful to the intestines. The germs sometimes cause raw ulcers in the intestines; the ulcers may be so deep that they cause a hole in the intestinal wall, and the patient may die. The hole through the intestinal wall is called a perforation. If the ulcer does not eat out a hole entirely through the wall of the intestines, it may cause the patient's death by bleeding. Such a bleeding is called a *hemorrhage*, — in this case a hemorrhage of the intestines.

Where Typhoid Germs Multiply. You have learned that the germ lives and multiplies in the human body.

With the exception of milk, the human body is the only place in nature where the germ can multiply. The typhoid germ does not live in the lower animals, and therefore they never can have typhoid fever. But the typhoid germ can live for a few days in water or milk, or it can live for a longer time in filth. It can live long enough to be carried to a new patient and cause the disease in him.

Typhoid Germs in Waste Matter. No doubt you are wondering how the germ can get into the mouth of the new patient, to be swallowed by him. There are several ways by which the germ can pass from the sick to the healthy person. For instance, the germs are swarming by millions in the unclean waste matter that is thrown off by the intestines. When we eat any food, the digestible portion of it is dissolved and absorbed by the stomach and intestines; but there always remains a certain quantity that is not digestible, and hence is useless to the body. This passes entirely through the intestines and is cast off from the body as body waste. This body waste from a typhoid patient is alive with typhoid germs. If you could see them, you would see that they are more numerous than blackbirds in the biggest flock of blackbirds you ever saw.

How Flies Carry Typhoid Germs. One single fly can carry enough of this unclean and dangerous material on one foot to cause a person to take typhoid fever. The fly acts as a messenger between the typhoid patient and the well person and causes the latter to become sick. The fly goes out into the back yard, where the unclean body waste from the sick room has been poured on the ground by careless people. He lights on it and puts his feet in it. The feet of the fly are covered with hair, to which the unclean material clings. The fly may then pass into the dining room or kitchen and walk over the butter or the jelly. Can you imagine how the fly leaves a trail of germs behind? Figure 15 shows a flat dish of jelly that a fly has crawled over. The germs have multiplied for twenty-four hours and have caused the spots which you see. Any one eating this jelly now would swallow more germs than there are people inhabiting the United States. If some little boy had eaten the jelly just after the fly squirmed across it,

Figure 15. — Tracks made when a fly walked across a plate of gelatine. Each dot is a colony of germs.

he would have been unable to see any trail, but would nevertheless even then have swallowed more germs than the number of inhabitants in your county.

Do you see how easy it is for the germs to pass from a sick to a well person?

Typhoid Germs in Drinking Water. The germs can also reach us by another route, and that is in the drinking water. Suppose there is a family living on a hillside, with the back yard higher than the front. The well will probably be near the house. A great many unclean things are thrown on the ground near the well, and as the back yard slopes up the hill, any rain that falls will tend to wash these unclean things back toward the well. A great many wells are cased in at the top with rocks or pieces of stone. Water can easily trickle through the cracks between the pieces of stone. In a loose soil the germs can soak through without being filtered out. The water may contain millions of typhoid germs that came from the body waste of a typhoid patient. If any one drinks the water of this well, he is likely to become ill with typhoid fever in about twelve or fourteen days; for it takes about that time for typhoid fever to develop after the first germs enter the

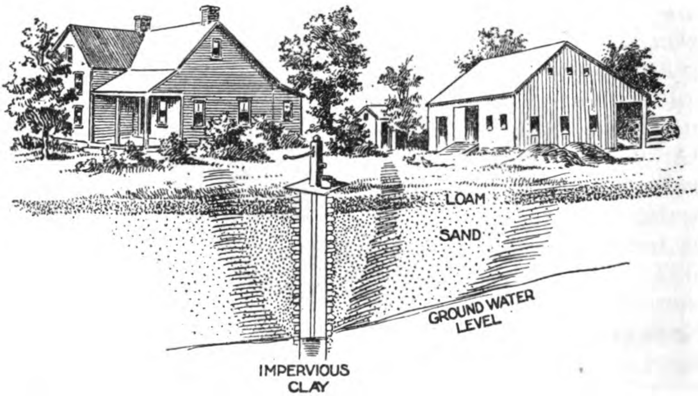


Figure 16. — Showing a well located in the wrong place. The drainage either seeps or overflows into the well.

body. Hence, in trying to trace the source of a case of typhoid, we always inquire particularly where the patient was, about two weeks before his illness began.

Typhoid Germs in Milk. Most typhoid is spread by flies, or by drinking water, but there is another way by which these dangerous and active little germs are frequently passed on from one person to another; namely, in milk. Dozens of epidemics have occurred in which practically all the sick people had been using milk from the same milk dealer. Typhoid germs multiply very rapidly in milk, and if milk cans are washed in water containing typhoid germs, or if a single fly lights on the milk, it can poison the whole can of milk. If this is mixed with other milk it will poison that, and there is thus no limit to the harm that may come from germs in milk.

There are several other ways in which germs can get into milk. One of the men or women handling the milk may be a typhoid carrier.

Typhoid Carriers. A typhoid carrier is a person who has the typhoid germs in his system, but who is not sick. Usually a typhoid carrier has had typhoid fever at some previous time, and although he has recovered his health, the germs of the disease have never left his body. This seems hard to believe, but is absolutely true. It is easy to see how a man could have a few germs in his body after he began to get well, but the typhoid carrier actually has many germs in his body for months or years after he has recovered. Look at Figure 43 and observe that the typhoid carrier is usually a healthy person.

When you studied the chapter on immunity, you learned how it is possible for a deadly disease germ to be harmless to individuals who are immune. In the case of a typhoid carrier, he is immune to the typhoid germ and cannot be injured by it; and yet the germ has the power to live in his body.

Dangers from Typhoid Carriers. Just think what terrible damage a typhoid carrier can do! Without knowing it, he can give this disease to those he holds most dear, as well as to strangers. The United States Army will not allow a known typhoid carrier to enlist in the army. He would be too dangerous to his comrades. Not many typhoid patients develop into typhoid carriers, however, and this is fortunate.

Necessity for Washing the Hands Frequently. A great many people get the typhoid fever germs by shaking hands with a typhoid patient or by handling his bed or clothing. Anything a typhoid patient has touched is likely to be soiled with the germs. In order to avoid getting the disease in this way, always, after having touched a typhoid fever patient or the things that he has touched, rinse the hands carefully in soap and water, or better in an antiseptic solution. No one who waits on or nurses a typhoid patient should cook for the family. If it is necessary for any one to do so, the hands should be thoroughly disinfected before entering the kitchen.

Now you have learned the most important ways in which typhoid fever is spread. There are many other ways also, as for instance by oysters, lettuce, radishes, and other articles of food, commonly eaten raw. Raw vege-

Figure 17. — Plate, knife, and fork; the patient should keep his separate from those of the family.

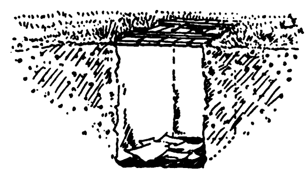


Figure 18. — Hole dug to receive typhoid wastes. The lid is to keep out flies. Disinfectant should be poured into the hole.

tables are positively dangerous wherever the soil in which they grow has been enriched with human waste matter.

Finding the Cause of Epidemics. There are certain ways in which we can form an idea as to how an epidemic is spread. It is important to ascertain the exact way in which a disease is spread in order to take steps to stop the infection.

(1) *The epidemic of typhoid fever spread by the fly* always occurs at a time when flies are plentiful; that is, in warm weather. An epidemic spread by the fly usually occurs in those parts of a town where there are most flies. An epidemic spread by flies is never sudden or explosive in its nature, but drags along through the summer, getting a little worse as August and September approach, and dying away after the first frost. In an epidemic spread by flies each case is usually near some other case.

(2) *The epidemic spread by drinking water*, if in a town with a public water supply, is usually explosive or sudden, and a dozen or possibly a hundred people will become ill in the same week. In an epidemic spread by drinking water, cases occur in widely separated parts of a town. An epidemic spread by drinking water usually follows certain cases of typhoid which have occurred upstream along the banks of the river supplying the town.

(3) *The epidemic of typhoid spread by milk* is likely to affect persons who take milk from a certain dairyman; the persons affected are all on one milk route. In an epidemic spread by milk, children and old people are especially affected, because they use most milk. Such an epidemic is likely to affect well-to-do people in cities, because they use more milk than poor people; but this point is not noticeable in small towns in Texas, where almost all citizens are able to get milk.

Disinfectants Used to Kill Typhoid Germs. Now comes the great question how to prevent typhoid fever. The most important thing is to kill all the germs as fast as they leave the body of the patient. This is best done by chemicals or drugs that are poisonous to germs. We call these chemicals *disinfectants*. In Chapter XIX, you will learn more about how to use disinfectants. Most disinfectants are poisonous to human beings as well as to germs, hence they should be applied only by grown people.

All body wastes, discharges, secretions, excretions, and all slops from the typhoid sick room, should be disinfected thoroughly. This may be done cheaply with chlorid of lime, or with pure or crude carbolic acid, or with corrosive sublimate, or by patented preparations made from coal tar. These are mentioned and described in Chapter XIX.

Method of Disinfection for Country Districts. Dig a hole two feet square and two or three feet deep in the back yard, at least one hundred feet from the well. First, disinfect the slops, then pour them into the hole, and have a closely fitted wooden or wire gauze lid to cover the hole to keep out the flies. (Fig. 18.) The method used had best be determined by the physician caring for the case.

Dangers of Carelessness. If you do not disinfect the body wastes from the patient, you are scattering sickness and death among your neighbors. It would be far better

Figure 19. — The slop bucket is the stronghold of typhoid fever.

Figure 20. — Disinfecting the linen. The bundle is dropped into the water without being undone.

to set free a dozen rattlesnakes in your back yard than to pour out on its surface the body wastes containing the living typhoid germs.

How to Handle the Laundry of a Typhoid Patient. It is not right to turn a lot of soiled linen from a typhoid patient over to a washerwoman or laundry without warning. In handling the soiled linen, the washerwoman or one of the laundry workers may get the disease. All soiled linen from the sick room should either be soaked in a disinfectant solution before being sent to the laundry, or should be wrapped in a clean sheet or pillow case, so that the washer-woman can drop it into the boiling water without touching the soiled linen.

The plates, knives and forks, and other utensils used by a typhoid patient should be kept separate from those of the family, and should either be soaked in a disinfectant solution or placed in a dishpan of water and boiled. These points will naturally be looked after by the physician, and in case a trained nurse is in attendance the physician will probably entrust all these things to her.

Length of Time Contagion Lasts. These precautions should be kept up until the physician declares the patient to be free from typhoid germs. At the present time it is impossible for a bacteriological examination to be made in each case, but Texas will not be free of typhoid fever until these tests are made regularly in all cases.

How to Avoid Catching Typhoid from Neighbors. But suppose that the case of typhoid fever is in a neighbor's family, how can we escape catching it? There are several practical things we can do. The most important is to use screens and sticky fly paper, and wage war on the flies of the neighborhood, in every possible way. We must also notice the lay of the land, to see if there is any drainage from our neighbor's premises on to our own. If he is on the uphill side of us, we must be extremely careful, because a rain may wash his back yard, and the washings may trickle into our well. If there is a reasonable doubt as to this point, we must boil the drinking water. The patented household filters are as a rule worthless. Those who object to the flat taste of boiled water can restore the taste by pouring it through the air a few times from one pitcher to another.

When Cistern Water is Dangerous. If a cistern is used on the premises, it is well to be careful about English sparrows and pigeons, which may carry typhoid germs on their feet and soil the roof. The germs thus left on the roof may wash into the cistern. Whenever possible the sunny side of the roof should be used as a watershed to collect water for cisterns, because the sun kills the germs on the roof.

When typhoid is occurring all around you, it is well to see first that your dwelling is free from flies; then convince yourself as to the purity of the drinking water. Then inquire as to your milk supply and your supply of raw vegetables and oysters. Persons who fear they have been exposed to typhoid fever will probably desire in some cases to be made immune by anti-typhoid vaccination.

Asiatic Cholera. This is a fatal disease, due to a little comma-shaped germ which, like the typhoid germ, is spread by unclean drinking water. It is not likely to enter Texas, unless brought in by ships passing through the Panama Canal. The way to prevent cholera is to quarantine those who are sick and to use drinking water which is free from germs.

IMPORTANT POINTS

1. Typhoid fever is a definite disease, and one attack is usually followed by immunity.
2. There are over nine hundred deaths reported in Texas from this cause each year.
3. At this time there is no better way to improve the health of the people of Texas than by directing our efforts against typhoid fever.
4. The typhoid germ does not multiply anywhere outside the human body except in milk.
5. Typhoid germs always come from the solid and liquid material thrown off from the body.
6. The fly is the cause of more epidemics of typhoid fever in Texas than has been realized in the past.
7. Drinking water is usually polluted by drainage water which runs into the well from the top.
8. By carefully observing certain facts it is possible to

decide with some accuracy whether a given epidemic is due to the fly, the water, or the milk of the community.

9. Typhoid germs can live in the body of a healthy man, and other people can catch the disease from him.

10. No person recovering from typhoid fever should handle the public milk or food supply of a city unless tested by a competent bacteriologist and found free from typhoid fever germs.

11. No person nursing a case of typhoid fever should handle the milk or food of a family.

12. A slop bucket is the stronghold of typhoid fever.

13. Typhoid vaccination is harmless and is valuable in preventing typhoid fever.

QUESTIONS

1. What are the two most common causes of the spread of typhoid fever in Texas? 2. How many deaths are reported in Texas from typhoid fever each year? 3. Can we accomplish anything by trying to prevent typhoid fever? 4. What kind of unclean material does the typhoid germ live in? 5. Suppose a large mass of decaying vegetables and small animals were left near a house, if there were no human waste material in it could it cause typhoid fever? 6. What part of a well is most likely to let the typhoid germs get in, — the top, the sides, or the bottom? 7. What part of the fly is especially likely to carry germs? 8. Why is it dangerous for a person just getting over typhoid fever to sell milk? 9. How do the typhoid germs get into milk? 10. Why should the nurse not make the bread for the family in case of typhoid fever? 11. After coming from the typhoid sick room, what should you do before eating? 12. What is a typhoid carrier? 13. When does a person become immune to typhoid fever?

CHAPTER VII. CONSUMPTION OR TUBERCULOSIS

Consumption is such a common disease that some boys and girls think they already know all about it. But common as it is, there are a great many interesting things about consumption that will surprise you when you hear them. For instance, there are about six people that get entirely well from consumption for every one that dies.

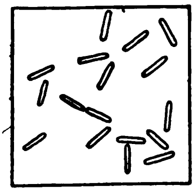


Figure 21. — The germ of consumption, called the tubercle bacterium.

Majority of People Have Consumption. Almost everybody who lives to be fifty years old has had consumption at some time during his lifetime. At least three out of every four men have consumption before they die. You wonder how we know they have consumption if they do not know it themselves. We know it because thousands and thousands of bodies have been examined after death, and a large majority of them have shown scars made by consumption germs. Many of these people—indeed, most of them — never dreamed they had ever had this disease.

The organs most often damaged by consumption are the lungs. The usual signs are a cough that lasts a long time, and loss of weight. Most people who cough constantly are consumptives.

The Lungs are Especially the Seat of Consumption. The lungs are so important in the spread of consumption that we shall not study consumption in the other organs to any extent; yet it is well to know that the consumption germ can live in the skin, in the intestines, in the bones, in the kidneys, in the coverings of the brain and spinal cord, and in fact anywhere in the body. By far the greater number of cases of consumption, however, are cases of consumption of the lungs. We have almost given up the use of the word consumption except in speaking of the lungs. When we mention the disease in the other organs we give it the longer name *tuberculosis*. We then mention the organ affected, as for instance, tuberculosis of the bones or of the hip.

The Germ of Tuberculosis. The germ of tuberculosis is a little rod-shaped bacterium. It cannot move, but remains still until something blows it or washes it along to a new place. This bacterium can live but a few hours if placed on a pane of glass in the sun; it can live a few days on the surface of the ground in a sunny place; but it can live for weeks and possibly months where it is dark and moist. It does not multiply, however, after it leaves the human body. A house that has been occupied by a careless consumptive who has spit on the floor is dangerous for months afterward.

Method of Spread of Consumption. It is easy to account for the spread of consumption, but the remarkable thing

Figure 22. — The careless consumptive spits on the floor; the spit dries and is swept up into the air with the dust; everybody in the room then inhales the dust and the germs.

is that so many escape the disease. Some people have consumption for years, and go about spitting on the floor, on the sidewalks, on the floor of street cars, and even on carpets. The sputum dries up, and people walk over it and grind it into dust; the wind blows it up into the air, and men breathe it into their lungs.

Evils of Dry Sweeping. There is nothing that spreads consumption germs so thoroughly as dry sweeping. One can take a broom and go into a room and raise a dust in three minutes that will float in the air for at least an hour or two, and will place germs, first in the nose of the sweeper, and then in the noses of all who enter the room, for a long time after the sweeping is finished. After the dust settles, it is there to be stirred up again, perhaps with the feather duster.

There is a remedy for this: we have plenty of water with which to sprinkle the floor, and we can stop spreading consumption in our homes at any rate. It is against the law in Texas for any porter or janitor to sweep a public building without sprinkling. (See Sanitary Code for Texas, in this book, Rule 54.)

How to Avoid Raising a Dust. There are several ways of avoiding a dust when we sweep our homes. We should have a floor as smooth as possible. It can be cleansed in several ways. If it is a hall, the floor may be oiled once a month and brushed up daily with a brush instead of a broom. In the case of a bedroom with a common pine floor, such as we find in the majority of Texas homes, dampened sawdust may be scattered over the floor before sweeping. In some places sawdust is scarce, and there pieces of newspaper can be dampened and scattered on the floor before sweeping. In all cases a brush is better than a broom. Rugs which can be taken out and shaken or beaten are not dangerous. Heavy carpets should be avoided, but if a carpet is in use, it should be swept with a carpet sweeper, or, better still, with a vacuum cleaner.

In dusting, a rag or cloth should be used, and it should be dampened with water or greased with raw linseed oil, so that the dust will stick to the cloth. It is not necessary to use any drug or chemical in the water. (See also Sanitary Code for Texas, Rule 54.)

Feather Dusters. Feather dusters are too dangerous to have in a dwelling occupied by human beings. It is all right to use them out in the open air to brush the dust off a buggy or an automobile, but dust in houses is dangerous. House dust is more dangerous than street dust, for two reasons: first, the sunlight of the street will kill any germ in a few days; and second, almost all disease germs come from human beings, and in and around the house there are more human beings and hence more disease germs.

Figure 23. — The feather duster is dangerous and should be replaced by the moist cloth. (Compare Figure 26.)

Consumption Spread by Coughing. When a consumptive coughs, he blows out a number of little fine drops of sputum. These droplets are so small that some of them float in the air like fog on a misty day. For this reason it is dangerous to have your face close to a consumptive when he is coughing or even when he is talking. Have you not noticed the saliva leap out of a man's mouth when he was talking? There are a great many droplets which, although invisible, may contain germs and are therefore dangerous. For this reason it is dangerous to sleep in the same room with a consumptive.

Outdoor Sleeping. No consumptive ought to sleep in a room. He ought to sleep in the open air, and this can always be arranged, especially in our Southern climate, where bitter cold weather seldom comes.

Kissing. A consumptive should never be kissed early in the morning until he has washed his face, and even then not on the mouth. Kissing him on the cheek is not dangerous immediately after he has washed his face. It is the dust and uncleanliness that are dangerous. It is always very wrong for a consumptive to fondle another person or to kiss any one on the mouth, especially a baby or a little child.

Consumption is Not Inherited. No child ever comes into the world with this disease upon him. But we can inherit a set of lungs that will develop consumption if the germs ever get into them. Even then we cannot possibly have consumption unless we get the germs into our lungs. Some are so fortunate, it seems, that even a fair number of germs can get into their lungs without remaining there. In some way the lungs are proof against consumption. Others are not so lucky, and as soon as the germ gets into their lungs, it multiplies and cause consumption. These germ-proof men and women are in good health and their strength is up to the standard. In general, it can be truly said that a person who is run down or overworked takes the disease more readily than one who is strong and in good condition.

Avoiding Tuberculosis from Milk. Cows have consumption, and their milk often contains the germs. Babies and small children using this milk are likely to get tuberculosis of the bones, of the intestines, or of the kernels along the side of the neck. The cow that has tuberculosis may look well. You have probably known people who were the picture of health and yet had consumption. It is the same with cattle; it is impossible to tell by outward appearances whether or not a cow is diseased. The veterinary surgeon can tell, however, by testing the cow. All cows that furnish milk for children's use should be tested by a good veterinary surgeon to find out if they have tuberculosis.

Consumption is Curable. Consumption is so common in Texas that every one ought to know something about the treatment of the disease. Consumption is curable. There are hundreds of healthy persons in Texas who have had it and have recovered, among them some of our most prominent men. Almost every man can point to some friend who has had the disease and has recovered.

There are four things to do in order to recover from consumption: first, sleep and live out of doors; second, eat plenty of good food, such as milk, eggs, light bread,

Figure 24. — The careful consumptive sleeps alone, and if possible he sleeps in the open air or in a window tent.

chicken, fish, and things of that kind; third, rest and save your strength, especially if you have fever; and fourth, keep in touch with a good physician to advise you about any special things that may be needed in your particular case.

How to Prevent Consumption. If we wish to prevent consumption, we must be sure that the rented houses which we move into are free from tuberculosis germs. Careful inquiry should be made in all cases before moving into a rented house. Find out if anybody has died there in the last year. If there has been any case of sickness in the house within twelve months, the house should be disinfected. A description of the best method of disinfecting a room will be found in another chapter.

Spitting. We should all be careful where we spit. Every one has to spit sometimes, and it is safe to spit into the toilet, into a spittoon containing water or disinfectant substance, on the ground in a sunny place, provided it is not on the sidewalk, or in a special paper handkerchief or cloth carried for the purpose. Those who have tuberculosis should carry cloths or paper handkerchiefs at all times, and after spitting in them should burn them. (See Sanitary Code for Texas, Rule 62.)

Duty of the Family. The most important thing a family can do to prevent the spread of tuberculosis is to stop the dry method of sweeping and dusting.

The Duty of the Government. The health department in every city should have a map showing where each case

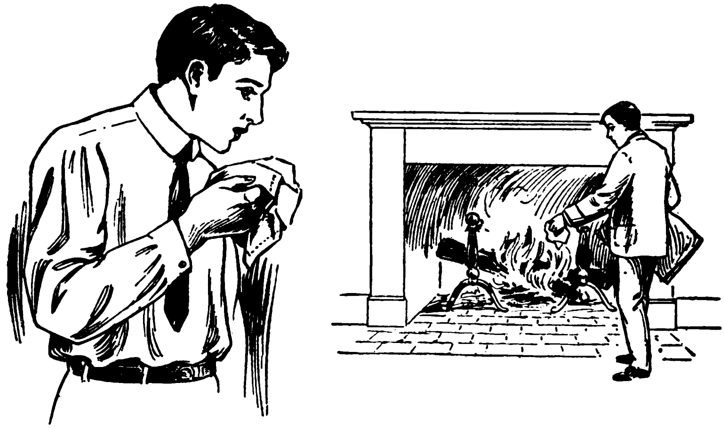


Figure 25. — The consumptive should spit in a rag or paper; the rag should be burned to destroy the germs in the spit.

of consumption occurs. When the house of a consumptive person is vacated, it should be disinfected before any one else moves into it. The city should also furnish free printed matter to the poor who have consumption, so that they may learn how to get well and how to keep from giving the disease to others. The city should have an outdoor hospital, or pavilion, for poor consumptives, as this would prevent them from spreading the germs. Only the larger cities can afford to have a visiting nurse to go into the homes of the poorer consumptives and actually teach them how to take care of themselves and others. All towns should have an inspector to see that the milk sold in the towns is pure. This is especially to protect the babies.

IMPORTANT POINTS

1. Consumption is the commonest disease on earth. A large percentage of all people who live to be fifty years old have had consumption at some time in life.

2. Consumption is curable, and a great majority of those who have it recover.

3. Consumption is not hereditary, but is catching; it is spread by a rod-shaped bacterium that is cast off from the body in the sputum.

4. The germs of tuberculosis can live for months in dark corners of dwellings, and all rented houses should be disinfected before being occupied.

5. Dusting and sweeping by the dry method is one of the best ways to spread consumption.

6. Babies and small children should never drink the milk from a tuberculous cow; the only way to be sure a cow is free from tuberculosis is to have her tested.

7. Careless spitting is dangerous.

8. The city government should keep a record of all consumptives, and should disinfect all houses that have been vacated by them.

QUESTIONS

1. What percentage of all persons have consumption? 2. Is consumption curable? 3. How is consumption spread? 4. Describe the germ of consumption. 5. Describe the proper method of sweeping a room; of dusting. 6. Give several precautions which tend to prevent consumption. 7. How long can the germ of consumption live in sunlight? In dark corners? 8. What is the danger in moving into rented houses? 9. Where should a consumptive spit? 10. Where should we spit? 11. Is consumption spread by milk? 12. Name some things the city government should do to limit the spread of consumption.

CHAPTER VIII. COLDS, GRIP AND PNEUMONIA

A great many disease germs are so harmful to the body that they cause disease as soon as they enter it. Consumption germs are of this kind. You never find consumption germs in a healthy person. But some other disease germs are not quite so harmful to a strong, healthy man, and they can live in his body without harming him. The man is too healthy and strong for the germs to injure him. But if this same man gets wet and chilled, especially when he is hungry and tired, the germs begin at once to do him harm.

The Germs of Colds, Grip, and Pneumonia. The germs which cause colds, grip and pneumonia are all of this kind. They are very common, and almost every one has some of them in his nose and throat all the time. But

Figure 26. — A moist rag should be used to remove dust.

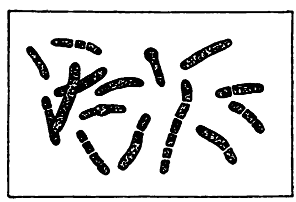


Figure 27. — The germs of grip or influenza, very highly magnified.

they cannot harm us as long as we are in good condition. If we stay out in the open air a great deal, eat plenty of plain, nourishing food, and do not expose ourselves to the weather without proper, warm clothing, the germs are powerless. But if we go hunting in rainy, windy weather and stay all day without eating or resting, or if we get our feet wet, especially when we are tired, the germs may cause a cold or something worse.

Pneumonia Dangerous to Drunkards. In no other disease does alcohol show its damaging effects so plainly as in pneumonia. It is a fact well known to physicians that a drunkard cannot withstand pneumonia as well as a person who does not drink. This is one proof that alcohol acts as a poison to the entire system, because pneumonia is a disease of the lungs and not of the stomach. Alcohol does not therefore limit its harmful effects to organs with which it comes in direct contact, but it weakens the entire system.

How to Avoid these Diseases. There are two ways to avoid grip and pneumonia. The first is to keep ourselves in good condition all the time. We can do this by regular habits of eating and sleeping, working and playing. We can also make ourselves hardy by spending a great deal of time in the open air and by taking cool baths regularly. We should start taking the cool baths in the summer time, not in the winter. We should also start the habit of remaining in the open air in the summer time. Then, as the winter wears on, we can keep it up, within reasonable limits.

The other way to avoid these diseases is to try to keep from getting germs from any one who is ill. Pneumonia germs from a severe case are more likely to cause the disease than pneumonia germs from the throat of a healthy person. You know, the pneumonia germ does occur in the noses and throats of healthy people. But these do not seem to be so harmful as the germs from an actual case of pneumonia. The same is true of grip. Many people who appeared to be strong and well have caught pneumonia and grip by going into a sick room; these people have not done anything to weaken themselves, and yet the germs overcame them. Therefore, no one should enter the sick room except for some good reason, and the hands should always be washed afterward.

The Value of Fresh Air. Plenty of fresh air in our living and sleeping rooms helps a great deal in keeping our strength up to the standard. Air is never bad because it is cold, but because we are not properly clothed to withstand cold. We can enjoy living an outdoor life if we wear enough clothing and use enough blankets.

The Sick Room. Everybody should know that certain precautions should be taken in every sick room. For instance, the linen from the patient and his bed should not be handled or flirted in the air, but should be carefully bundled up and dropped into boiling water or into a disinfectant solution, as already described. Those who have to care for the patient should always wash their hands carefully after leaving the room, especially before eating. Dusting and sweeping by the dry method should not be done in the sick room, nor indeed in any room. The plate, knife and fork should be kept separate from those used by other members of the family.

IMPORTANT POINTS

1. The germs of colds, grip, and pneumonia are frequently found in the air passages of healthy persons.

2. Exposure to wet and cold weather upsets the body of these persons slightly and enables the germs to multiply and produce toxins and so cause disease.

3. The germs of any of these three diseases sometimes attack strong, healthy persons who have not been exposed to cold weather.

4. We can avoid these diseases in two ways: first, by keeping ourselves strong, so that the germs cannot overcome us; and second, by keeping away from persons sick with these diseases.

5. In the sick room the usual precautions should be taken as follows: a separate set of eating utensils should be kept for the patient; the linen should be handled cautiously; dusting and sweeping should be done by the moist method; all persons entering the sick room should wash their hands after leaving.

QUESTIONS

1. Name some germs that cause disease whenever they enter the human body. 2. Name some germs which sometimes live in

the human body without causing disease. 3. Suppose you have the germs of grip living in your nose and mouth; tell how you could bring on an attack of grip. 4. Does the germ of pneumonia or grip ever act like the typhoid germ and cause illness in a strong, healthy person? 5. Give three precautions to remember concerning the sick room. 6. What proof have we that alcohol does harm to the lungs?

CHAPTER IX. DIPHTHERIA AND MENINGITIS

The germs of diphtheria and meningitis can live in the nose or throat without causing disease. It is more usual, however, for them to cause dangerous illness. Both diphtheria and meningitis are dangerous and contagious.

Diphtheria, a Dangerous Disease. Diphtheria caused almost as many deaths in the United States in 1910 as typhoid fever, but in Texas it causes only about one fourth as many deaths each year as typhoid fever. In 1911, diphtheria caused two hundred and eighty-one deaths in this state; diphtheria stood sixth among the communicable diseases as a cause of death.

How the Diphtheria Germ Injures the Human Body. The diphtheria germ lives in the nose and throat. It may

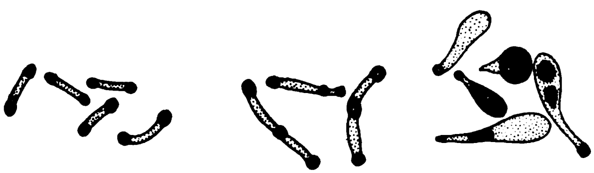


Figure 28. — The germ of diphtheria is cast off from the body in spit; also found in the pocket handkerchief.

cause the lining of these passages, called mucous membrane, to swell and stop up the throat so that the patient cannot get his breath; the germ may also do harm by the poisons or toxins formed in the patient's body. These toxins are absorbed into the blood and may be carried to the brain and cause death. The toxins made by diphtheria germs cause the patient to have fever and flushed cheeks.

Diphtheria Antitoxin. It is indeed fortunate that we have an excellent remedy against diphtheria. You have learned already something about how antitoxin is made. This antitoxin or serum almost always cures the cases in which it is given early, and for this reason it is well to have all sore throats examined, so that if diphtheria is present, no time will be lost. While the death rate from the disease has been lowered by the treatment with serum, there are still far too many cases. *It would be much better to prevent the disease than to have to cure it.*

How to Prevent Diphtheria. The most effective way to prevent diphtheria is to isolate every case until the person is well and the germs have left the throat, and to give a small dose of antitoxin to every one who has been exposed to the disease. A person who has received a small dose of antitoxin cannot catch the disease for several weeks. It has been found that the germs live for some time in the throats of patients after recovery. For

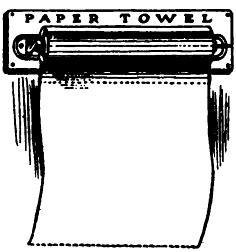


Figure 29.—All public towels should be of paper and should be used only once before being thrown away.

Figure 30. — White blood cells containing meningitis germs.

this reason, wherever possible, an examination of the throat should be made before allowing a patient to go about in public. It is not always practicable to do this, however, and the doctor will have to use judgment in letting the patient go.

Seeing that healthy boys and girls can carry the germs in their noses and throats without knowing it, it is wise to avoid using the public drinking cup and the public towel. One should avoid borrowing pencils and things of that kind from others, for many people have the foolish habit of moistening their pencils in their mouths.

The diphtheria germs do not multiply outside the body, except when some careless person allows them to get into milk. They always come from the human body.

Epidemic Meningitis. This disease is an inflammation of the coverings of the spinal cord, and is due to a little oval germ which lives in the nose and throat and spinal canal of those who are sick. We call this little germ the *meningococcus*, and as you can see in Figure 30, it occurs in pairs. The picture shows that the white cells of the blood have swallowed some of the meningitis germs.

The spinal cord is composed of nerves and nerve cells, and is almost like a part of the brain, as you will learn later. It is well protected by tough coverings, and it is on these coverings that the meningitis germ especially lives. The germ causes inflammation of the coverings of the cord. It is not the only germ that can live in this position and cause inflammation, but it is the only germ that causes these symptoms in epidemics. When other germs attack the coverings of the spinal cord, it is almost always in the course of an illness in which other parts of the body are also affected; the typhoid germ, for instance, can affect the coverings of the spinal cord and, in a sense, cause meningitis, but the typhoid germ never causes epidemics of meningitis.

Meningitis Carriers. It seems altogether probable that the germ of meningitis can live in the nose and throat of a healthy individual without causing any inconvenience. From this person's throat the germ can spread to other people and cause meningitis.

How the Meningitis Germs Enter our Body. These germs enter through the nose and mouth. For this reason all those who have been close to a meningitis patient should be very careful, for they may be carriers of meningitis, although they are not sick.

Value of the Serum Treatment of Meningitis. Before the introduction of the serum treatment of meningitis, almost all persons who had it died; and those who did not die were usually blind, crippled, or otherwise injured. Since the use of this treatment, more than half the patients have recovered, and it is rare to find any serious defects as a result of the disease. Even now, however, meningitis is one of the most dangerous diseases known. Probably it is the most dangerous epidemic disease that ever affects our country.

How to Prevent Meningitis. The best things to do to prevent meningitis from spreading are to isolate the sick and to use sprays in the nose and throat to destroy the germs. All those who have been near a person suffering from meningitis should keep their throats sprayed, in order to protect themselves as well as others; for one who feels entirely well can carry the germs and may spread the disease.

IMPORTANT POINTS

1. Diphtheria is a dangerous contagious disease of the nose and throat, and is due to the diphtheria germ.

2. The diphtheria germ itself does not live all through the body; the toxins cause fever and other symptoms of diphtheria.

3. Diphtheria can be cured by antitoxin, if it is used early.

4. The secretions from the nose and throat contain the diphtheria germ, and therefore public drinking cups and public towels are dangerous.

5. Meningitis is the most dangerous epidemic disease that occurs in our State.

6. It is due to a germ that lives in the coverings of the spinal cord, and also in the nose and throat.

7. Meningitis is spread in the same manner as diphtheria, by secretions from the nose and throat.

8. In both diphtheria and meningitis, the germs can live in the nose or throat of a healthy person, without causing inconvenience.

9. The serum treatment of meningitis has cut in half the death rate from this disease.

10. Diphtheria and meningitis are prevented in the same ways: isolate the sick; avoid handling articles such as public

drinking cups and public towels; and remember that healthy persons may be disease carriers.

QUESTIONS

1. Where do the germs that cause diphtheria and meningitis enter our body? 2. How does the diphtheria germ injure us? 3. What is a diphtheria carrier? 4. What is the cure for diphtheria? 5. Explain how the public drinking cup spreads diphtheria. 6. What is the most dangerous epidemic disease that occurs in Texas? 7. Where does the meningitis germ enter the human body? 8. What is the cure for meningitis? 9. What symptoms formerly followed meningitis if the patient recovered? 10. Would it be dangerous for the nurse in charge of a meningitis patient to mingle in a crowd of people? Why?

CHAPTER X. MALARIA, YELLOW FEVER, AND DENGUE

Malaria, or Chills and Fever. This is just as definite a disease as measles, and we know more about it than we know about measles. We know the little germ that lives in our bodies and multiplies, causing malaria; its name is the malarial parasite, or *plasmodium* of malaria. The germ cannot live anywhere in the world except in two places: first, in certain parts of the human body, especially in the blood; and second, in a certain species of mosquito. The germs of malaria cannot live in all parts of the human body. For instance, if we accidentally swallowed or breathed in some of the germs they would not live, but would die in our bodies and do us no harm. If we drank water containing the wiggle tails, which are only young mosquitoes, they could not cause malaria. In order to live in the body, the germ must enter it in one particular way.

How the Germ Enters our Bodies. How, then, does the germ of malaria get into our body? It comes in through the bill of the mosquito when it bites us. That is the only way it ever enters our bodies. Now, it is strange, but true, that a malarial patient cannot give malaria to any one else unless the mosquito acts as a messenger or carrier to others. In other words, if one member of the family has malaria, it is perfectly safe for him to remain in the same room with the others, so long as he uses a mosquito bar or net to keep the mosquitoes from reaching him.

How Malaria Is Spread. The first man to prove that the germs of malaria grow and develop in the mosquito was Dr. Ronald Ross of England, who made this discovery on August 29, 1897. Two years later the United States Army Commission proved at Havana that yellow fever also is spread by the mosquito, and in no other way. In Chapter III you have already learned that Dr. Carroll and Dr. Lazear lost their lives while making these investigations. This was in 1900. The same year Dr. William

Thayer of Baltimore and Dr. Albert Woldert of Texas demonstrated that in this country the Anopheles mosquito harbors malarial germs, which it injects into persons, thus spreading chills and fever.

While our American scientists were making these brilliant discoveries, Dr. Sambon and Dr. Low of London spent

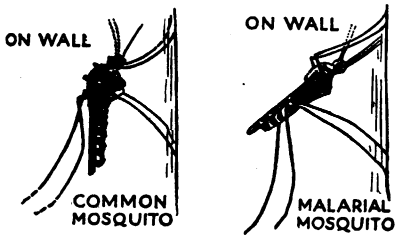


Figure 31. — Observe that the malarial mosquito stands out from the wall.

the summer in the Italian Campagna swamp, near Rome, where almost every one had malaria during the summer. These physicians, however, slept behind mosquito-proof screens, and as you will imagine, they remained free from malaria.

Where the Mosquito Gets the Germs. We must not forget that the mosquito is harmless unless it has previously bitten a patient sick with malaria. We say mosquitoes carry malaria from one man to another. If the mosquito could think and talk, it might say, "Human beings carry malaria from one mosquito to another." One man cannot give malaria to another without the mosquito, which acts as a messenger or carrier. The mosquito sucks human blood. It thrusts its bill down into the skin of a malarial patient deep enough to suck out some of the blood, together with the malarial germs present in this little drop of blood. The malarial germs multiply in the body of the mosquito. Later, when it bites some other human being, the germs pass through the bill of the mosquito and enter the body of the unfortunate person, who then becomes sick with malaria.

Prevention of Malaria. When we get rid of mosquitoes, we prevent malaria. The best method of getting rid of the mosquitoes is to kill the wigglers by pouring oil over the water in which they live. Wherever possible, we should do away with all standing water, a point fully discussed in Chapter XVII.

Screens Prevent Malaria. There is something, however, which we can all do that will almost surely protect us from malaria; that is, screen our homes. In Texas we have so delightful a climate, and so little really cold weather, that we need screens all the year round to protect us from insects. Copper or brass wire screens are most durable, but they are expensive. Galvanized iron wire screens are next best. Ordinary wire screens do not last long. All the screens should be fine-meshed, so as to keep out all mosquitoes. The variety of screen that has sixteen meshes to the inch is best. Mosquitoes easily crawl through the twelve-mesh screens, or through bars with coarse mesh.

Figure 32.—Note that all doors and windows are screened and that the porch is also screened in. This house is safe from malaria in any climate.

Mosquitoes may be driven out of the house by burning certain things in a room, so as to cause a dense smoke, as for instance chips, leaves, or pieces of old cotton cloth. The fumes from burning sulphur or insect powder kill mosquitoes. Whenever sulphur is burned indoors, it should be remembered that the fumes, if inhaled, are irritating and dangerous. Burning sulphur has a tendency to sputter, and pieces of it may leap out of the bucket or tub and set fire to the house. The fumes of sulphur will tarnish metals, and therefore metal articles should be taken from a room before fumigating it with sulphur

Old-fashioned Ideas. Malaria cannot be spread by damp air or by the beautiful mists that may be seen early in the morning rising over the swamps. A home in

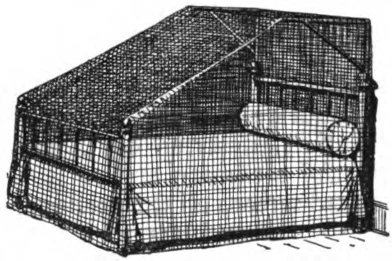


Figure 33. — A mosquito bar can always be procured, and it is the next best thing to a screened room.

the swamps or river bottoms can be made perfectly safe from malaria by screens and mosquito bars or netting; for malaria is a disease that is spread in one way, only, and that is by the mosquito.

Other Diseases Spread by the Mosquito. There are two other diseases which are carried by the mosquito; namely, yellow fever and dengue fever.

Each Disease Spread by a Separate Kind of Mosquito. It is remarkable that only certain kinds of mosquitoes can carry these diseases, and a particular kind of mosquito carries each separate disease. One kind of mosquito, called *Anopheles*, carries malaria; another kind, called *Stegomyia*, carries yellow fever; and another kind, called *Culex*, carries dengue. Figures 53, 54, and 55 show the three kinds. But, remember, the mosquito cannot carry the disease unless it has bitten some one who is sick with it.

Yellow Fever. This is a very fatal disease, and in olden times it was much dreaded in Texas, because when it occurred in epidemics it killed many people. The people thought it was due to "something in the atmosphere," or "something that blows up from the swamps." They were right, for that "something" was simply a mosquito. Nowadays we know how to stamp out the disease because we know that it cannot be carried in any way except by the mosquito. Yellow fever is not so much dreaded now as formerly. And yet we are so close to Mexico and Cuba and Brazil that once in a while some ship will sail into our Texas ports with yellow fever on board. When this occurs, we can prevent the spread of the disease by killing all mosquitoes on board. It does no good to quarantine against the mosquito. If a yellow fever patient entered a town, he could not give the disease to any one if he tried, except by mosquitoes. Of course, if a town does not rid itself of mosquitoes, a quarantine is needed.

Dengue. This is an unpleasant disease to have, but not a dangerous one. About every ten years it appears in Texas, and sometimes it sweeps all over those parts of the state where mosquitoes are most abundant. It has occurred so many times while there was also an epidemic of yellow fever that some people formerly thought it was related to yellow fever. It is really an entirely different disease, and an attack of yellow fever does not protect one from dengue. There were thousands of cases of dengue in Texas in the late summer and fall of 1907, and the disease did a great deal of harm by leaving people weak and nervous, and also by frightening them. To prevent another epidemic, each city and town should have a health department to destroy the breeding places of mosquitoes. In addition, all homes in Texas should be screened.

IMPORTANT POINTS

1. Malaria is due to a germ that lives half its life in the blood of a malarial patient, and the other half in the body of a certain kind of mosquito.

2. Malaria will disappear from Texas when all our people use screens and mosquito bars.

3. Yellow fever and dengue fever are also spread by the mosquito, but each one by a different kind of mosquito.

4. By doing away with all breeding places for the mosquito, and by screening the sick, we do away with yellow fever, malaria, and dengue.

QUESTIONS

1. What connection has malaria with the location of a house? 2. Name two places where the malarial germ lives. Does it live anywhere else? 3. Suppose you should swallow the eggs of a mosquito, would you be likely to have malaria? 4. If you drink water from a cistern in which there are wigglers, will it give you malaria? 5. Suppose you were bitten by a hundred mosquitoes, none of which had bitten a malarial patient, would you contract malaria? 6. Name two other diseases caused by mosquitoes.

CHAPTER XI. QUARANTINABLE AND REPORTABLE DISEASES

One very old method of limiting the spread of a communicable disease is by *quarantine*. The word quarantine is from an old Italian word meaning forty, because people on board a ship sick with contagious disease were not allowed to leave the vessel for forty days. Today the word quarantine usually means confining people to certain premises or places in order to stop the spread of communicable diseases.

Modern Quarantine. Our ideas of quarantine have changed as we have learned more about the cause and spread of diseases. For instance, in cases of smallpox the patient is held in quarantine a certain number of days after he recovers; but in diphtheria, since the germ can live in the throat for some time after the patient recovers, the patient is not kept for a definite number of days, but until his throat is free from diphtheria germs. Sometimes this is a few days after the attack is over, and sometimes it is six months. For this reason many people are allowed to go free sooner than they otherwise would, because their throats contain no germs; but other patients are kept much longer than formerly, because if permitted to go about in public, they would be dangerous to the public health.

We still have to rely on a definite time limit, however, in many diseases. The following are declared by the laws of Texas to be quarantinable: Asiatic cholera, plague, typhus fever, yellow fever, leprosy, smallpox, scarlet fever, diphtheria (membranous croup), epidemic cerebro-spinal meningitis, dengue, typhoid fever, epidemic dysentery, trachoma, tuberculosis, and anthrax (charbon). (See Sanitary Code, Appendix B.)

The length of time patients are held in quarantine varies with the different diseases and depends on the length of time during which patients may communicate the disease after recovery from the illness.

Quarantine of Exposed Persons. Sometimes people in health are quarantined because they have been exposed to a disease and it is feared they may develop it. In this case the length of time they are kept in quarantine depends on how long it takes the disease to develop after one has been exposed to it. This period, while the disease is developing, is called the *incubation period*, from the fact that the germs are being incubated in the body. After

Figure 34.—Nurse under quarantine. Note the sheet over door.

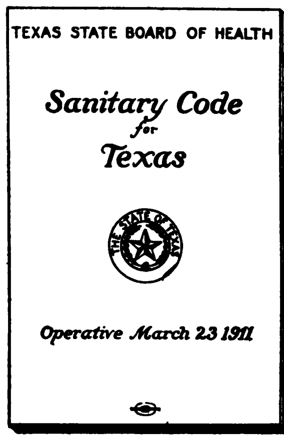


Figure 35.—This code is the law in Texas. (See Appendix B.)

the germs are introduced it usually takes them several days to multiply sufficiently to cause symptoms of disease. Even before symptoms develop, however, such patients can convey the disease to other people.

Reportable Diseases. We should especially note that the law requires reports to be made and complete records to be kept of all quarantinable diseases, including typhoid fever and tuberculosis. The physician in attendance on these cases is required by law to report them to the State Board of Health, and both the local and the state health officers keep a record. The records of cases of tuberculosis are required by law to be kept privately, and no one except the proper authorities has the right to see them. This is done because no person has a right to know from what a patient is suffering except the officers of the law who are protecting the public health. At present there are so few cases of these diseases in many communities in Texas that complete records are not kept. As our state grows, however, it will be more necessary to observe the law, and we need improvement in this regard even now. Investigate and see if these diseases are reported in your community. If they are not, make up your mind to do your part in future and get them reported.

How to Get the Sanitary Code. The State Board of Health at Austin will take pleasure in sending to your school a copy of the Sanitary Code, containing many of the legal rules concerning quarantine and health matters generally. It would be well for each class to get a copy of this, as it is the law of the land. Is it well enforced in your county or town? Good citizens should be willing to submit to quarantine whenever they have a communicable disease, even though it is in a mild form, because fatal cases may arise from very mild ones. The Sanitary Code for Texas is given in abbreviated form in Appendix B.

Flagging the House. As a rule, quarantine consists in keeping the sick individuals in a certain room or house and preventing any one from entering or leaving this room or house, except the nurse and physician, who know how to avoid carrying the disease to others. A placard is tacked outside warning the public not to enter, or a yellow flag is placed on the house.

Elsewhere in this book you have learned what the following diseases are and how they are carried from one patient to another: Asiatic cholera, plague, yellow fever, diphtheria dengue, meningitis, typhoid fever, tuberculosis, and trachoma. We will take up in order the following communicable diseases: typhus fever, leprosy, smallpox, and scarlet fever.

Typhus Fever. This is another name for jail fever, or ship fever, and it is not closely related to typhoid fever. It exists at all times in Mexico, and is found in unclean

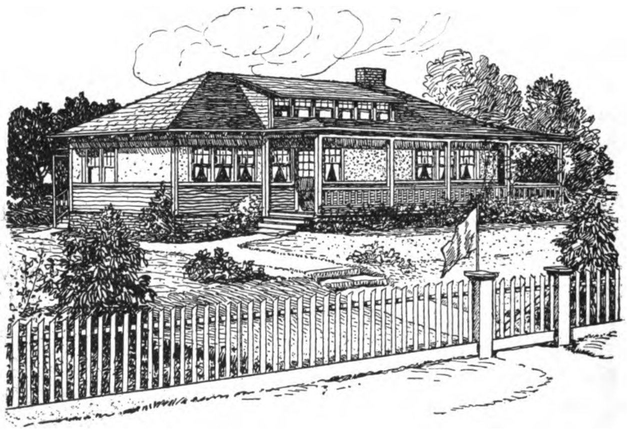


Figure 36. — A house under quarantine. The sign on the porch is usually omitted. The flag is yellow or red.

houses. It is carried by certain insects that live in the clothing or hair of uncleanly people. These insects are called body lice, or head lice. It is not likely that this disease will gain much foothold in Texas.

Leprosy. This is a very old disease and one that is very terrifying to most people. It is due to a germ that resembles the tuberculosis germ. The germ of leprosy is found in the sores and in the secretions from the nose of lepers. It is not likely to attack many people in Texas.

Smallpox. This is a dangerous disease that causes fever and pustules or little pockets of pus over the skin of the body. It is one of the most contagious diseases known, and a high percentage of those exposed take the disease.

Fortunately this is one disease which we know how to prevent. Vaccination is a certain preventive of smallpox, as you have learned in Chapter V.

Scarlet Fever. This is simply another name for scarlatina. There is no difference between the two. It is a very contagious disease, and the germs can live in the garments of a scarlet fever patient for many months. Up to this time we do not know the nature of the germ that causes scarlet fever, and so can do very little to prevent its spread except to quarantine all scarlet fever patients. The greatest care is necessary in the way of destroying or disinfecting all toys, clothing and other things of the kind, that have been in the room with a scarlet fever patient.

Diseases which Exclude Children from School. There are several diseases that affect children especially, in which quarantine is not usually enforced. These diseases are measles, mumps, whooping cough, and chicken pox. They are alike in that they attack a large percentage of all children in this country. If one escapes these diseases, however, as a child, he may have them after he is grown up. Pupils with any of the four diseases mentioned are debarred from school.

Measles. This is by far the most important of these diseases. It causes about six thousand deaths in the United States every year. In Texas alone two hundred and twenty-two deaths from measles were reported in 1911. Measles is more fatal among infants and children under five years old than among boys and girls from five to fifteen years old. This should lead mothers to be careful to prevent their children from having measles before they reach the age of five or ten. It is not uncommon to hear mothers say that they want their children to have measles and get through with it. But this is not wise, for measles is a serious disease, especially among little children.

Whooping Cough. This is also a serious disease when it attacks babies and very young children. It is due to a germ that resembles the grip germ. The whooping cough germ cannot easily be carried in the clothing, but is usually spread from one child to another by direct contact. That is, the germs pass from the hand or face of one child to the hands of another; or from the hands or lips of one child, to some toy, and from it to the hands or lips of another child. It is not hard to ward off whooping cough. All

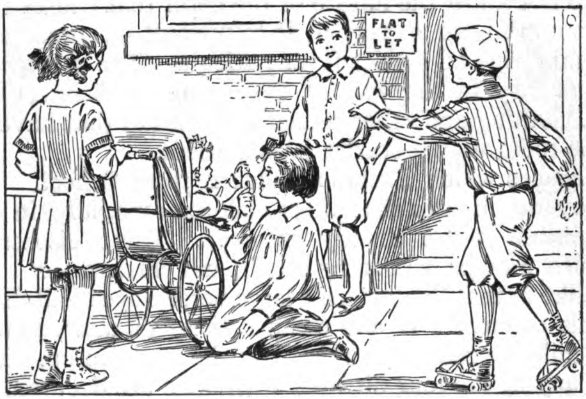


Figure 37. — Little children should not be allowed to mingle on the street with other children, as whooping cough and other diseases are caught in this way.

that is needed is to keep babies away from other children, except those known to be healthy. Whooping cough, measles, and scarlet fever each cause about the same number of deaths each year in the United States. *Whooping cough is fatal in one fourth of the cases occurring among infants under two years of age.*

How these Diseases Are Spread. To spread either of these diseases, some solid or liquid particles must pass from the body of the sick into the body of the well. The particles which spread the diseases are especially the droplets of saliva that fly out of the mouth when the patient coughs or speaks. In measles and scarlet fever it may be that the dried particles of skin that scale off are concerned in the spread of the disease, although this is not proved. The germ of measles and that of scarlet fever have not been found, and it is possible that they are so small that they are invisible with our strongest microscopes. You have already learned that some germs are so small that they cannot be seen at all, as for instance the germ of rabies or hydrophobia.

IMPORTANT POINTS

1. Quarantine is one method of preventing the spread of disease, but in some cases we have learned a better way; in many cases we still resort to quarantine because we do not know a better way of preventing the spread of the disease.

2. The laws of Texas declare that the following diseases are quarantinable: typhus fever (not typhoid), Asiatic cholera, plague, yellow fever, smallpox, scarlet fever, diphtheria (membranous croup), dengue, and leprosy.

3. The following diseases are quarantinable only to the extent that they debar pupils from school: measles, mumps, whooping cough, and chicken pox.

4. The germs of smallpox and scarlet fever live for many months in garments and on toys and furniture, and retain their power to cause the disease.

5. The risk of contagion of measles and of whooping cough does not last over two weeks, as a rule; *these diseases are dangerous to small children and babies.*

QUESTIONS

1. What is the old or original meaning of the word quarantine? 2. Why do we not hold all dangerous contagious cases exactly forty days now? 3. Name two quarantinable diseases in which the contagion will last a long while in clothing. 4. Is it wise for mothers purposely to expose little children to the measles? 5. Name three diseases that should exclude pupils from school, but which are not of sufficient importance to require a full quarantine. 6. What is the best way to prevent whooping cough in babies? 7. Why is it important to prevent infants and young children from getting whooping cough? 8. How can you get a copy of the Sanitary Code for Texas?

CHAPTER XII. PELLAGRA AND HOOKWORM DISEASE

Much attention has been paid in recent years to hookworm disease and pellagra, two diseases that may be called new in the United States.

The Cause of Pellagra Disease Unknown. In Texas more attention has been paid to pellagra than to hookworm, although hookworm disease is more prevalent and more easily curable than pellagra. Not knowing positively the cause of pellagra, we can do nothing to prevent it. It is not very catching, if at all, and yet we ought to be careful about stating that it is not catching till we know more about the cause. No precautions have usually been taken to prevent its spread, and yet in this state no case has ever caused a second case among the nurses or physicians and others who have cared for the patients. At the same time, there have been several families in which more than one case has occurred. The main symptoms of pellagra are: a redness resembling sunburn on the back of the hands, face and neck, diarrhœa, and nervousness. Many pellagra sufferers get well, and if medical attention is sought early no one should be discouraged on account of this disease. A change to a cool climate is probably beneficial.

Hookworm Disease in Texas. Hookworm disease is not uncommon in the thickly settled parts of Texas, espe-

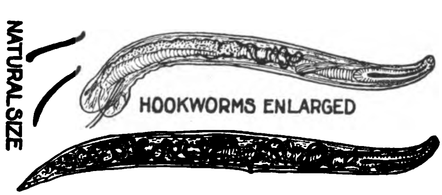


Figure 38. — Male and female hookworm.

cially in the sandy soils of East Texas. From one fourth to one half of the first three thousand school children and citizens examined in Texas by the Rockefeller Hookworm Commission were found to have hookworms. It is a preventable and curable disease.

Where the Hookworm Lives. The hookworm that causes this disease lives in the small intestines and sucks blood from the intestinal wall. The disease shows itself especially by lack of blood in the patient. People who have hookworm disease are usually pale and weakly. They lack energy and strength. They are often nervous and have fickle appetites. But, after all, no especial symptom is caused by the hookworm that is not caused also by other diseases.

Diagnosis of the Disease. The only way surely to know whether anybody has hookworm is by the use of the micro-

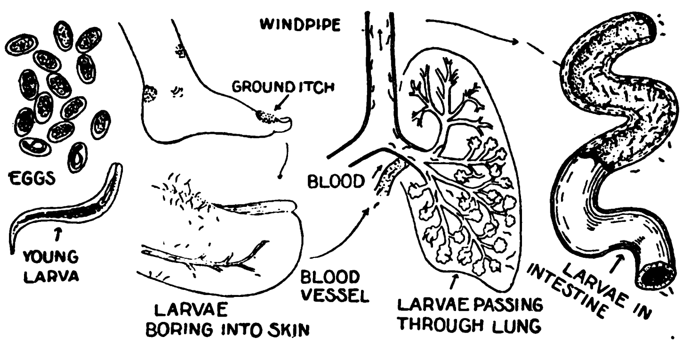


Figure 39. — The hookworm eggs hatch into little worms which penetrate the human skin, enter a blood vessel, pass to the lungs, enter a bronchus, crawl up the windpipe, are swallowed and thus reach the small intestines.

scope. The worm lays eggs, and these eggs leave the intestines in the waste matter that is thrown off from the body. The eggs are too small to be seen without a microscope.

The Hookworm. This is a small worm about half an inch long, and it remains in the intestines. The eggs, however, pass out, and are dangerous, as they cause the spread of the disease. Just how the eggs hatch out and get into man's body is a wonderful story. It almost surpasses belief, but we are forced to believe it, because there are actual photographs showing the worm in all the stages of its journey from one person to another.

The egg hatches soon after it leaves the body or intestines of the patient. A little worm is formed from the egg. This worm gets on the skin of children, especially those who go barefooted, and goes into the skin, causing a little blister where it enters. This blister is known as the "ground itch." We know now that ground itch is nothing but one stage in hookworm disease. The worm passes through the skin and gets into a blood vessel. It passes up the blood vessel to the lungs. Here it eats its way through the wall of the blood vessel and gets into a bronchus, or bronchial tube. The worm squirms along the bronchial tube and gets to the windpipe and then to the throat. It then turns back down the throat and passes through the stomach into the intestines, where it begins its usual life. It is probable that some hookworm eggs are swallowed directly and are hatched in the stomach or intestines.

Dangers of Soil Pollution. When unclean wastes from the body are allowed to be poured out on the soil, the ground is not only unclean, but is dangerous, because a child walking along barefooted is likely to develop ground itch, which is the beginning of hookworm disease. Such children are backward in their growth, stunted, and weakly. They are not well, and do not play and study like healthy children.

Need of Sewers and Sanitary Outhouses. The best preventive of soil pollution is a good sewer system, but this cannot be had on the average farm. The next best thing is well-built outhouses. Pictures near the end of this book show a poor and a good kind of outhouse.

No wastes from the human body should ever be allowed to be thrown on the ground, as there are too many diseases which may be spread in this way. People who do not know they have any disease may be disease carriers.

Tapeworms and Round Worms. Other intestinal worms that cause disease in man are tapeworms and round worms. The eggs of the tapeworm leave the body as in the case of hookworm. The eggs of the tapeworm then get into the body of the hog or beef or fish, where they hatch into young worms. When we eat the flesh of these animals, if it is not well cooked, the young worms begin their life in our intestines. All meat should be inspected carefully by a meat inspector, and it should be well cooked to prevent the spread of tapeworms and of other diseases.

Thymol. This is the remedy for hookworm, but as it is not a harmless drug, it should be employed under the advice of a physician. No oil of any kind or butter should be eaten after taking thymol.

IMPORTANT POINTS

1. Pellagra is a disease somewhat new in America, but fairly well distributed over the Middle and Southern parts of the United States.
2. We do not know the cause of the disease.
3. Pellagra is often curable, and a cold climate seems to have a beneficial action, both in the prevention and in the cure of this disease.
4. Hookworm disease is due to the presence in the small intestines of small worms about half an inch long, which attach themselves to the wall of the intestines and suck blood.
5. We know how to prevent and cure hookworm disease: it can be prevented by avoiding soil pollution from body wastes, and it can be cured by small doses of thymol.
6. The small hookworms, just after they are hatched, can pass through the skin and find their way, by a complicated route, to the small intestine, which is their home.
7. The sanitary outhouse, built according to the directions

given near the end of this book, will prevent the spread of hookworm disease.

QUESTIONS

1. Do we know the cause of pellagra? 2. What is the cause of hookworm disease? 3. Where do the hookworms live in the body? 4. What symptoms do they cause? 5. Where do the worms enter the body? 6. Describe their journey from the skin of the feet to their final home. 7. What is the most effective way to prevent the spread of hookworm disease? 8. Is there a cure for the disease? 9. In what kinds of meat are we likely to find tapeworms?

CHAPTER XIII. BUBONIC PLAGUE

The Panama Canal brings Texas into much closer connection than ever before with China, India, and the Eastern countries generally. It is possible that persons suffering from bubonic plague may land in one of our ports and start

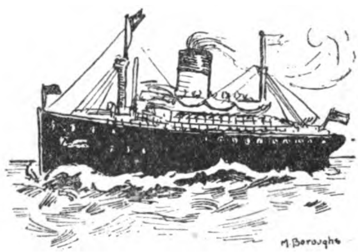


Figure 40. — Ships from foreign countries might bring bubonic plague into our seaports.

a focus of the plague in our state. We should know that the disease is spread by fleas from animals such as rats and squirrels, so that we can protect ourselves intelligently.

Animals Also Have Plague. Plague, or bubonic plague, as it is called, is one disease that man shares with lower animals. It is due to a germ that lives in the lymph nodes, in the lungs, and in the blood. The disease kills a high percentage of those who have it and it also kills many rats and ground squirrels. There was a plague center in California not long ago. Only squirrels and rats were affected there, but now and then some hunter catches the disease from squirrels. Plague is also found in some of the South American countries.

How Plague Is Spread. Fleas from gnawing animals, such as squirrels and rats, carry plague to human beings. The huntsman kills a squirrel and picks it up. The fleas leave the dead squirrel, get on the man, and bite him. The man develops the disease.

Why Rats Are Objectionable. Rats are dangerous, since they carry other diseases as well as plague; and they are very expensive, because of the quantities of grain which they destroy.

It is wise to make all premises as nearly rat proof as possible. This can be done in the following way: Wooden walks should be torn up and replaced by concrete or gravel. The residence should be at least eighteen inches above the

Figure 41. — Plague affects squirrels.

Figure 42. — Rats spread plague.

ground, measuring from the lowest joist. The barn and chicken yard should have concrete floors, and chicken wire of small mesh ($\frac{1}{2}$ inch) should be used. The woodshed should have no floor, and the wood should be piled on platforms at least two feet high. Garbage should be kept in an iron can with close-fitting lid. All grain should be stored in a metal container. If the premises are rat proof, a little poison exposed on cheese or meat will kill all the rats, because the rats will be driven by hunger to eat the poisonous bait.

In case plague should occur in Texas, quarantine would not do much good. The rat and the ground squirrel would have to be exterminated.

IMPORTANT POINTS

1. Plague is epidemic in the Far East, and hence it may enter Texas.

2. Plague is spread principally by the fleas which are found on rats and ground squirrels.

3. In case plague should break out, we could probably soon

get it under control, but after it gets a start among the rats and squirrels it is a very difficult matter to exterminate it.

4. The proper way to guard against plague is to exterminate the rat, and if necessary the ground squirrel and all the animals that harbor fleas and are subject to plague.

QUESTIONS

1. How is bubonic plague spread? 2. What countries are afflicted with plague today? 3. In what state of the United States has plague existed and among what animals? 4. How could we prevent the spread of plague if it should appear in one of our seaports?

CHAPTER XIV. DISEASE CARRIERS

You have learned that it is possible for a healthy person to have disease germs in his throat or elsewhere in his body. This is particularly true of typhoid fever, diphtheria, meningitis, pneumonia, and grip. We call people who walk about carrying these dangerous germs, *germ carriers*, or *disease carriers*. It is hard to realise that this kind of thing is possible, but we must believe it, for many reliable men, and men of good judgment, have investigated the matter and proved it to be true.

Figure 43. — A typhoid carrier handling milk is very dangerous. Typhoid carriers are usually in good health, but are dangerous to others.

Typhoid Carriers. In the case of typhoid fever, the carriers are usually people who have had the disease a year or two before. By carefully examining all who have had typhoid fever, certain scientists have found that some healthy men have the typhoid germ in their intestines, or in their kidneys. Many people have caught typhoid fever from these carriers, who were proved to have typhoid germs in their bodies.

Dr. Robert Koch, the great scientist who discovered the bacterium of tuberculosis, said that if the typhoid carriers could be prevented from spreading typhoid fever, the disease could be stamped out. The particular danger with typhoid carriers is that many of them are cooks, bakers, dairymen, and the like. One typhoid carrier in New York was a cook and caused twenty-six cases of typhoid in seven different families.

Diphtheria Carriers. It was a surprise to many doctors when it was discovered that the diphtheria germ could be found in the throat of healthy boys and girls. This fact, however, is well proved. The right way to apply quarantine to a family that has had diphtheria is to examine their throats and let the persons go free as soon as their throats are found free from the diphtheria germ. The same is true of meningitis.

Meningitis Carriers. Meningitis is such a deadly disease, especially when not treated by serum, that it seems almost unbelievable that the meningitis germ should live in any one's throat without making him sick. But this is most certainly true, and it explains why people fall sick with meningitis when they have never been near a meningitis patient. Without knowing it they have been near a meningitis carrier.

Figure 44. — A diphtheria carrier. Diphtheria carriers are usually in good health, but are dangerous to others.

How to Avoid Carriers. Every applicant for employment in a bakery, kitchen, restaurant, or other place where food is handled should be asked if he has had any contagious disease, especially typhoid fever, within two years. If he has had such a disease, he should be required to show by a certificate from the local health officer that he is not a disease carrier.

Care of Convalescents. Every person recovering from typhoid fever should consider himself a possible carrier, until proper bacteriological examinations have proved otherwise. If there is no laboratory in the town they live in, persons who have to handle food for others should communicate with the State Bacteriologist at Austin in order to get the proper tests made.

Uncleanly Habits Dangerous. Uncleanly habits are always dangerous, because persons who appear healthy may be disease carriers. Such habits as putting pencils or coins in the mouth, eating without washing the hands, or spitting on the floor, sooner or later lead surely to disease.

IMPORTANT POINTS

1. Some disease germs, such as the germs of consumption, are so harmful that they invariably cause disease whenever they live in the human body.

2. Other disease germs usually cause disease when they live in the body, but can live in the bodies of certain persons without causing disease.

3. A healthy person who has disease germs living in his body is called a disease carrier.

4. Other people may be killed by the disease germs which are harmless to the disease carrier.

5. Typhoid fever, diphtheria, and meningitis are spread by carriers.

6. Persons have been known to carry the typhoid germs for years after recovering from the fever.

7. Typhoid carriers are especially dangerous when they work in dairies, kitchens, bakeries, restaurants, or other places where food is handled.

8. It is impossible to tell whether a typhoid convalescent is a carrier except by a laboratory examination for the bacteria.

QUESTIONS

1. Name three diseases spread by carriers. 2. Can you tell a typhoid carrier by his appearance? 3. How do you explain the fact that the germs in a disease carrier do not make him sick? (See Chapter IV.) 4. In what occupations are disease carriers most dangerous to the public? 5. How can disease carriers be discovered? 6. Suppose you catch typhoid fever from a carrier or from a mild case, is your case likely to be mild? 7. How can we avoid danger from disease carriers? 8. Why are uncleanly habits dangerous even when no sick persons are near? 9. To whom may those persons apply who desire to be treated to see if they are carriers?

CHAPTER XV. INSECTS WHICH CARRY OR SCATTER DISEASE

The important fact has many times been pointed out in these pages that disease germs are derived from the bodies of persons who are sick. The germs of disease are carried from the sick to the healthy in various ways: in the air, in clothing, by insects, by means of drinking cups and towels, by contact, in our food, and in our drinking water. The house fly carries typhoid and other germs to our food, and blood-sucking insects transfer the germs of certain diseases from the blood of the sick to the blood of the well, thereby causing disease. Mosquitoes are responsible for distributing yellow fever, malaria, dengue fever, and several other diseases. Ticks spread disease among men, among cattle, and among chickens. We now consider it almost a rule that any insect which lives on the blood of any animal is likely to convey disease from one of those animals to another.

The Stable Fly. The common stable fly is often mistaken for the commoner house fly, but, unlike the latter,

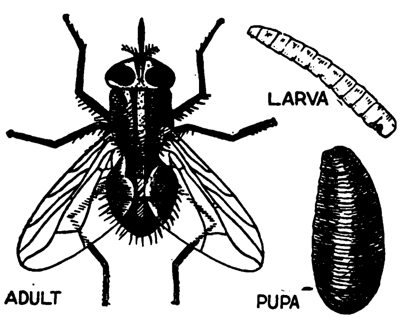


Figure 45.— Stable fly.

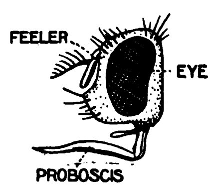


Figure 46. — Feeler, eye and proboscis of stable fly.

it is able to pierce the skin and suck blood. Facts have recently been brought to light which seem to prove that the stable fly is the active agent in the spread of infantile paralysis, a dreaded disease of children. This discovery was made by Professor C. T. Brues of Harvard University, who is a graduate of the University of Texas, and Dr. P. A. E. Shepard of the Massachusetts State Board of Health; and it has been confirmed by Dr. M. J. Rosenau of Harvard Medical School.

The Tsetse Fly. In East Africa there is a terrible disease known as the sleeping sickness. This disease is transmitted by the tsetse fly, another blood-sucking insect about the size of a house fly. It is thus seen that flies are among the most dangerous enemies of the human race.

Fleas. Fleas are insects that have no wings and have hind legs adapted for hopping. They live on all kinds of warm-blooded animals. The fleas that live on rats and ground squirrels are most dangerous to man, because these animals may become infected with plague, the germs of which are carried from the living or dead rat to man. To fight plague, therefore, we must make war on the rat and the ground squirrel, as has been done in California in recent years. We have not had plague in Texas, but it may come from Asia on ships passing through the Panama Canal, or from South America.

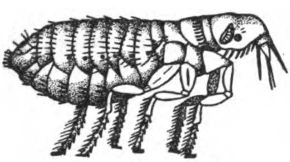


Figure 47. — Flea.

Lice. Body lice transfer typhus fever or jail fever from the sick to the well. This disease occurs in Mexico. Proper sanitary measures are almost sure to prevent its introduction into Texas.

Ticks. Ticks are not strictly insects, but are much like them. How many legs has a tick? A spider? An insect? Ticks have been proved to carry tick fever from cattle to cattle. The disease is deadly to imported cattle unless they are made immune by a special kind of vaccination, such as that described in Chapter IV. Cattle shipped out of Texas have to be dipped in a solution that kills ticks.

Another kind of tick is responsible for carrying Rocky

Mountain spotted fever to people. This disease originated in the Bitter Root Valley of Montana, where it causes about a dozen deaths annually. It also occurs now in other states.

IMPORTANT POINTS

1. Any insect that has the habit of sucking the blood of an animal is likely to carry or spread disease from one animal to another.

2. The stable fly bites persons and thus transfers from one person to another the germs of the disease known as paralysis of children.

3. The tsetse fly of Africa, also a biting fly, carries from one person to another the germs of a dangerous disease known as sleeping sickness.

4. Fleas from rats and ground squirrels carry the germs of plague and thus spread the disease.

5. Lice are responsible for the spread of typhus or jail fever.

6. Ticks spread disease among persons, among animals, and among chickens.

QUESTIONS

1. What kind of insects are especially likely to carry disease? 2. Name five insects known to carry disease. 3. What insect causes the spread of plague? 4. What disease does the stable fly spread? 5. What disease do lice spread? 6. What diseases are spread by ticks?

CHAPTER XVI. THE HOUSE OR TYPHOID FLY

Description of the House Fly. The house fly may be called one of our domestic animals, for it is found almost exclusively about the habitations of man. Since it cannot bite like its cousin the stable fly, it has until recently been considered perfectly harmless. It is a pretty creature, with a pair of gauzy wings, compound eyes, and lively habits.

Parts of the Fly. Studying the different parts of the fly will enable us to understand how the fly carries disease germs. All parts of the body of the fly, especially the feet (Fig. 49), are covered with stiff hairs well adapted for catching up filth particles containing disease germs. The

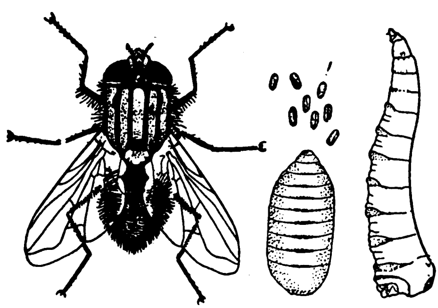


Figure 48. — This picture (after Howard) shows the eggs of the fly, and then the larva and pupa which the egg changes into before it finally becomes a grown fly. The larva is called a maggot.

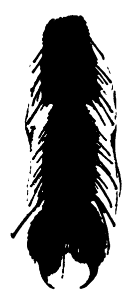


Figure 49. — The foot of the house fly.

last joint of each leg of the fly carries, first, a pair of claws fitted for holding on to rough surfaces, and second, a pair of pads between the claws. The pads have short knobbed and sticky hairs, by which the fly is enabled to walk on smooth surfaces such as a window pane, or upon the ceiling. No doubt these acrobatic feats have all seemed wonderful to you. Would you not suppose that these sticky hairs could also take up dust and dirt containing germs of typhoid or diphtheria? The *proboscis* is the name we give to the tongue or sucking tube of the fly, and on account of the presence of numerous hairs and bristles, this also is a good collector of filth and disease germs. (See Figure 50.)

How the House Fly Scatters Disease Germs. Thus we see that we should look with fear and disgust upon this pretty creature. It is really the poisoner of millions of persons. The house fly has fitly earned its new name of typhoid fly. It likes filth. It visits the back yard or the sick room of a typhoid patient, where careless people have placed the patient's body wastes. It covers the bristles and sticky hairs of its feet with filth and germs, and then flies into the kitchen or dining room and crawls over the bread and meat and jelly. If the typhoid-laden fly drops into a can of milk at a dairy, the germs multiply therein and may infect dozens of consumers of the milk. The fly may carry germs from the body wastes of one baby sick with summer complaint to the milk bottle with which another baby is fed, causing another case of sickness and perhaps death. If a consumptive spits upon the sidewalk, it is possible for flies to carry the germs from the sputum to the candy eaten by a boy or girl living close by. The fly frequently carries filth several hundred feet. Figure 15 shows a plate of gelatin over which a fly had been allowed to walk. At first no tracks could be seen, because the germs left by the feet of the fly were too small. But in twenty-four hours each germ had multiplied into a colony of thousands of germs. These colonies of germs are shown in the picture.

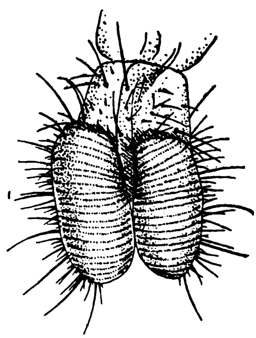


Figure 50. — The proboscis or "tongue" of the house fly.

Life History of the Fly. The female fly usually lays her eggs, about one hundred in number, in the manure of animals, especially in that of horses. The egg hatches in less than a day into a legless, wormlike *larva* or maggot. Each larva feeds upon the manure until full grown, when its outer shell turns hard and brown. The insect is then said to be in the *pupa* or resting stage. In the shell a wonderful change takes place, for soon this breaks open at one end and out slips the mature or *adult fly*. In about ten days, during average weather, the fly passes through the egg, larva, and pupal, to the adult, stage.

How to Reduce the Number of Flies. Flies are plentiful wherever filth or excrement is plentiful. If we remove the barnyard manure once a week, we remove with it all the young flies in the larval or egg stage. A good plan is to have a box or bin (Fig. 51) in which to keep the rakings from the stable and barnyard. The bin should be fly proof and its contents should be hauled off once a week or oftener. It is much easier to prevent the hatching of flies than to catch them in the adult or winged stage. Fly traps are often useful for catching adult flies. There are several good patterns on the market.

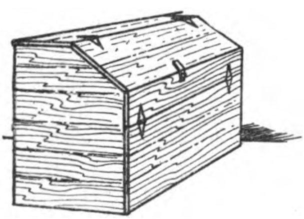


Figure 51. — A fly-proof manure-bin with lid.

Observation Work. Secure a number of fly traps and place them in good situations. Use different bait (moist bread, molasses, sugar-water, meat, etc.) in the different traps, so as to find out which is most attractive. It is also interesting to capture a fly and study the parts (eyes, wings, proboscis, feet, feelers, balancers, etc.) with a magnifying glass. Disinfect the fly by rolling it in formaldehyd or hydrogen peroxid. and wash the hands in soap and water after handling it.

When the flies get into the house in spite of all we can do to prevent it, they should be killed. Liquid poisons in sweetened water are sometimes used, but they are not to be recommended for the reason that the poisoned flies are likely to fall into the food and thus do as much damage as living ones. Sticky fly paper is the best means of killing the flies. The flail (Fig. 52) can be used to kill flies as well as mosquitoes that gather on the inside of our screen doors and windows. If we darken a room, with the exception of one window, the flies will gather at this window, where they may be killed.

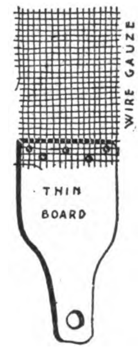


Figure 52. — Fly killer.

Avoiding Disease. To prevent the carrying of germs to our food we should first try to keep down the number of flies by removing their breeding places, and second, screen our houses so as to keep the flies out of our kitchens and dining rooms. If you doubt the need of screens, take some lime and throw it on to the flies out near the stable or closet. Within an hour you will probably find flies with lime on their backs on your dining-room table. The best screens that can be obtained at reasonable cost are those made of galvanized wire. To keep out mosquitoes as well as flies, the wire gauze should have no less than sixteen meshes to the inch.

Disinfection of Body Wastes. After taking all the precautions mentioned, we still have not done the most important thing to prevent the spread of disease. *If we do not expose germ-laden filth to the fly, there will be no germs for the fly to carry.* The most important thing to do to prevent the scattering of typhoid and other diseases is to disinfect the body wastes of the sick, as described in Chapter VI. Typhoid fever is a filth disease. Flies can scatter the germs only when the germs are placed where the flies can get to them.

IMPORTANT POINTS

1. The foot and the proboscis of the fly are covered with hairs, so that filth clings to them.

2. The fly alights on filth, and then carries germs on its dirty feet into unscreened dining rooms and kitchens.

3. The egg of the fly hatches to form a maggot; the maggot eats and grows until at length it becomes a pupa; the pupa rests a few days and hatches to form a full-sized adult fly.

4. The egg can pass through all the stages and form an adult fly in ten days.

5. Hauling off manure from the barnyard is the most effective way of preventing flies.

6. Screens should be used to keep flies out of the house.

QUESTIONS

1. How is the house fly adapted to gathering germs? 2. Explain how the fly places dangerous germs on butter, jelly, or other articles of food. 3. Give the different steps in the development of the fly from the egg. 4. How long does it take the egg to develop into a full-grown fly? 5. What are two important things to do in preventing flies from spreading typhoid fever?

CHAPTER XVII. MOSQUITOES

In Texas mosquitoes cause hundreds of deaths, which are chiefly the result of *malarial fever*, or what is more commonly known as chills and fever, malaria, or simply chills. In all cases it is the mosquito that takes the germ of malarial fever from a person sick with chills and fever and injects these germs through its proboscis into the

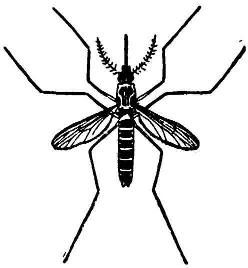


Figure 53. — Yellow fever mosquito (Stegomyia).

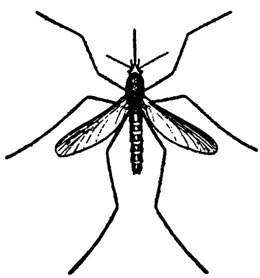


Figure 54. — Ordinary or dengue mosquito (Culex).

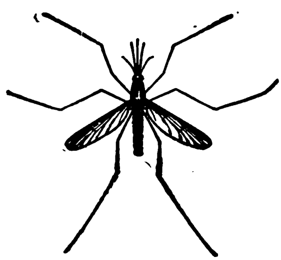


Figure 55. — Malaria mosquito (Anopheles).

blood of a healthy person, thus producing malaria. The germ of malarial fever is known as the *malarial parasite*.

Dengue fever makes its appearance in Texas from time to time; and when cases do come in from Mexico and elsewhere, mosquitoes are here to spread the disease. *Yellow fever* threatens to slip in from South America every summer, but this will probably be prevented by the watchfulness of our quarantine officers. Yellow fever is not likely to become epidemic in Texas again in the present advanced state of scientific knowledge. The study of the mosquito is important mainly from the standpoint of preventing malarial and dengue fevers.

Description of a Mosquito. The mosquito is an insect with a single pair of wings and a pair of balancers. For our present purpose the most interesting part of the animal is the proboscis, or bill. This is not a simple affair, but a whole set of instruments in itself. There are six sharp-pointed pieces in the proboscis for piercing the skin and making the blood flow. There is also a tube with which to suck up the blood; this tube is the duct through which the mosquito injects its saliva into the human skin. This saliva carries with it the germs of the particular disease of which the mosquito is a carrier.

How the Mosquito Scatters Disease Germs. The germs of malaria are sucked up through the proboscis of the mosquito and carried into its stomach. Here the germs cause knots or cysts in the stomach wall and multiply in countless numbers. In fourteen days the germs are mature and break out of the stomach wall of the mosquito and enter its salivary glands. If the mosquito then bites a person, the germs pass into the blood with the saliva which the mosquito injects into the wound.

Kinds of Mosquitoes. Yellow fever, malaria, and dengue are each carried by a particular kind of mosquito. Figures 53, 54, and 55 show the three kinds, all of which are found in Texas.

Observation Work. Secure a number of mosquitoes and try to identify them. This is not easy, even after looking at the pictures. The yellow fever mosquito (Stegomyia) has white markings in the shape of a lyre on the thorax and has striped legs. The malarial mosquito (Anopheles) has spotted wings, and when at rest stands at an angle from the wall (Fig. 31). The common mosquito (Culex; Fig. 31) holds its body parallel to the surface on which it rests.

Breeding Places of the Mosquito. To destroy these insect enemies of ours we must learn their breeding places and the habits of the young mosquito. We can keep the adult insects out of our houses, but we cannot kill them after they have grown wings and flown away. We may, however, easily keep down their numbers by filling up or draining their breeding places, and so getting rid of their young.


Figure 56. — Rain barrel with lid.

Everybody knows that the wiggler of our ponds and puddles is the young stage of the mosquito, but not everybody realizes what large numbers of mosquitoes may grow up in a small quantity of water. A tin can may catch enough rain water to raise a thousand mosquitoes in a summer. The rain barrel or the overground cistern is often a source of a continuous stream of mosquitoes throughout the season. Roof gutters may become clogged and hold water after every rain. Water troughs, hoof prints of cattle in wet ground, urns in cemeteries, and even a neglected vase inside the house may harbor mosquito wigglers.

The remedy for all this, and the easiest way to get rid of mosquitoes, is to destroy their breeding places. City and county authorities should see to it that useless accumulations of stagnant water are drained. Necessary ponds and tanks should be stocked with fish which eat the wigglers. Tin cans should have holes punched in them and should be carried off, and other such breeding places of the mosquito should be removed. The rain barrel and cistern should be made absolutely mosquito proof with screen covers (Fig. 56) and strips tacked over cracks.

By referring to Figure 60 you will see a cistern with the top open and exposed to mosquitoes. This cistern could be made more sanitary by covering it with boards, or, better still, with boards and cloth.

Life History of the Mosquito. Before laying a batch of eggs the mosquito must gorge itself with food, such as the blood of animals or man. It then deposits its eggs on the surface of the water, where they swell up and float. The eggs of the dengue mosquito are in a raft-like mass of two hundred to four hundred (Fig. 57); those of other mosquitoes are scattered singly on the surface of the water (Fig. 58). The eggs hatch in half a day, and come out wigglers, or larvæ. These feed on tiny particles of organic material. It is interesting to watch the brushlike mouth parts as they rake in the food. The larvæ of the Anopheles or malarial mosquito lie flat upon the surface of the water (Fig. 58); larvæ of other kinds feed at various levels and float with the head downward in the water.

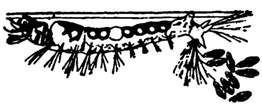


Figure 57. — Showing eggs, larva, and pupa, or the different stages in the development of the ordinary or dengue mosquito.

When the larva becomes full grown, it stops eating and becomes a pupa (Fig. 57), on the inside of which the adult insect develops. When the adult is ready to emerge, the pupa splits open at the back, and slowly the mosquito comes forth, pulling out its legs, feelers, and wings. It uses the skin it leaves behind as a raft until the wings are quite dry. After this it flies away.

How could one witness this magic transformation from worm to winged insect without thinking of the butterfly and the beautiful Greek story of Psyche, typifying the soul?

Observation Work. It is easy to rear mosquitoes in the school room. You may go down to the pond and find eggs, larvæ, and pupæ, and bring them to school in a glass jar. It is best to use the water in which they are found. Study all the stages. See if the larvæ change their skins. Watch the adults emerge. You may also set out a jar of rain water where mosquitoes abound, and the next morning you will probably find eggs on the surface of the water. Drop a single cooked bean or bread crumb into the rain water for the larvæ. If you wish to keep some adult mosquitoes in a cage, capture a dozen or so, place them in a cage, and feed them a slice of banana. Let the mosquitoes also have a tumbler of rain water in which to lay their eggs.

Destroying Mosquitoes. Besides removing the water in which the larvæ and pupæ live, there is another way of killing them. In Figure 57 both pupæ and larvæ are shown at the surface of the water, with the breathing tubes protruding into the air. If we pour oil on the water, the oil will spread over the surface in a thin film. The wiggler, therefore, dies for want of air.

Observation Work. Every school should organize an anti-mosquito brigade. Let the pupils look up and report all of the breeding places of mosquitoes in the school ward or school district.

Experiment. Place a few wigglers in each of two tumblers of water. To one tumbler add one drop of kerosene oil. Keep the other tumbler entirely free from oil. Note result.

Adult mosquitoes that succeed in getting into our houses can be killed with the flail (Fig. 52), on the inside of our screens, where they gather about dusk.

Screens. Some of the worst yellow fever and malarial districts of the world (Havana and Panama) have been made habitable to man by draining pools of water and by the use of screens, thus doing away with mosquitoes. Screens are necessary in all parts of Texas, both against flies and against mosquitoes. The river bottoms of the state can be made quite safe for white people by the use of screens on doors and windows of dwellings. If a person

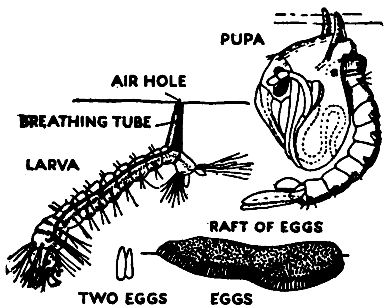


Figure 58. — Eggs and larva of the malaria mosquito.

has malaria, he should be carefully screened off from the other members of the family, and every precaution taken to prevent the access of mosquitoes, which might carry the disease to others.

IMPORTANT POINTS

1. Malaria is spread by the Anopheles mosquito and in no other way.
2. Dengue is spread by the Culex mosquito and in no other way.
3. Yellow fever is spread by the Stegomyia mosquito and in no other way.
4. The proboscis of the mosquito is sharp pointed and contains a tube for sucking blood.
5. The germs of malaria are sucked up from a malarial patient, and after multiplying in the wall of the stomach of the mosquito, are injected beneath the skin of other persons, causing malaria.
6. Mosquitoes breed in ponds, tin cans, rain barrels, cisterns, roof gutters, water troughs, and wherever there is stagnant water.

7. The egg of the mosquito hatches into a larva (called a wiggler); the larva leads an active life for a few days and goes into the resting stage, when it is called a pupa; the full-grown mosquito comes out of the pupa.

8. We can prevent the multiplication of mosquitoes by draining ponds and by preventing water from standing.

9. Screening gives immediate protection against mosquitoes.

QUESTIONS

1. Can malaria or dengue be spread without mosquitoes? 2. Describe the proboscis of the mosquito. 3. Explain how the mosquito gets the germs of malaria from a patient. 4. Name six common breeding places of the mosquito. 5. In what way can we get immediate protection against mosquitoes? 6. Why is it more necessary to screen a patient with malaria than one sick with meningitis? 7. Point out the eggs, larva, and adult of the malarial mosquito; also the adult in resting position.

CHAPTER XVIII. KEEPING GERMS OUT OF OUR DRINKING WATER

The most harmful things in drinking water are not the mineral matter, but the germs of disease which the water may contain. Of course there are poisonous waters, such as the strong gypsum waters found in certain parts of Texas, and there are some stagnant pools that are so full of filth that they would not serve as drinking water; but, on the whole, the only dangers that lurk in drinking water are in the form of disease germs, and in this country typhoid germs are the most to be feared.

Appearance of Water Not a Good Test. Disease germs are not visible except when placed under a microscope or

Figure 59. — Lad drinking from artesian well.

viewed in large numbers, and it is impossible to tell, by looking at water or tasting it, whether it is free from dangerous germs or not. There are many wells and springs which furnish water of a pleasant taste; such water may seem to be perfectly clean, and yet it may contain hundreds of typhoid germs in each drop. It is important to realize how impossible it is to judge a specimen of water by its appearance and taste. A much better way to form an opinion as to the purity of water is to examine into the source of the water.

Kinds of Water Used in Texas. In general there are five kinds of drinking water used in Texas, as follows: rain water, shallow well water, spring water, river water, and deep well water.

Rain Water. This is perfectly pure when it falls, but after it has fallen on a roof that has been soiled by English

Figure 60. — The uncovered cistern is a breeding place for mosquitoes.

sparrows and pigeons, it may become polluted from disease germs. Underground cisterns subject to either overflow or seepage may contain germs of typhoid fever. Water should be gathered in a cistern from the sunny side of the roof only, as sunlight destroys germs. The gutters should be cleaned as often as necessary. Water from winter rains only should be allowed to flow into the cistern. Open cisterns may serve as breeding places for mosquitoes and thus do great harm, as you have learned in Chapter VI.

The Shallow Well. This is the source of most of the drinking water used in many parts of Texas. A well of this kind is usually less than a hundred feet deep. Practically all wells, except the deep or artesian wells, are shallow. The shallow well is one of the most dangerous sources of

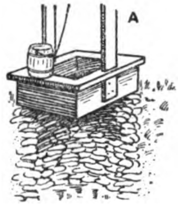


Figure 61. — This well is poorly constructed; water can leak through the platform or through the sides of the well. A rope and bucket should not be used.

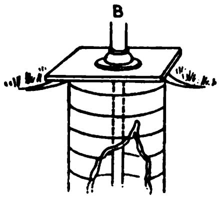


Figure 62. — This well is properly constructed. The platform is watertight. The sides of the well are water tight. The pump is better than the bucket and rope.

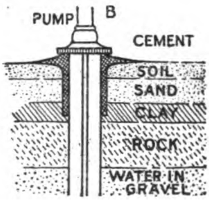


Figure 63. — The concrete curb should be prolonged downward to the layer of clay, which does not allow germs to pass through.

water, but it can be made reasonably safe in most instances. In nine cases out of ten, the fault is not in the lay of the land, but in the way the well is cased in, the method of drawing the water, or other conditions that can be corrected. When we take into account the fact that usually the water in a shallow well has filtered or seeped through at least twenty feet of closely packed earth, we must conclude that most of the germs would be filtered out. It is certainly true, however, that if a well is placed close to a cesspool, especially on the downhill side, and if this cesspool is filled with unclean material month after month, sooner or later some disease germs will pass through the soil and into the well. A well is seldom placed, however, in such a dangerous position. We may therefore conclude that the germs which seep into the bottom of a well with the water are not so important as the germs that spill in over the top of the well or those that trickle in through leaks in the sides. Not only should the well be cased in, but the platform or cover should be watertight, in order to prevent the well from being soiled with material dropping off the shoes of the persons drawing water.

Casing of Wells. Figure 61 shows a typical faulty shallow well. Point out four errors in the construction of this well. Figure 62 shows the same well with the faults corrected. The model well shown in the picture is cased from bottom to top with concrete rings, which are fitted together with cement so as to make a perfectly watertight joint. These rings are usually molded to fit a standard well, three feet in diameter, and it takes about thirty dollars to pay for the casing in of a well thirty feet deep. The concrete rings are superior to brick or stone, because they have fewer joints. The model well shows the concrete rings built up two feet or so above the surface of the ground, and when this is done, the mound around the surface of the well is unnecessary. It is a good rule, however, to hill up the soil around every well to prevent surface water from running in at the top. To make a still better well, a two-inch cap of concrete can be placed over the mound for a distance of three feet from the well in every direction, as shown in Figure 63.

Many wells in Texas could be made comparatively safe in the manner shown in Figure 63. Here the upper layers of the earth are porous and admit surface drainage into the well. By continuing the cement wall into the layer of clay, all chance of seepage into the well would be cut off and the well thus made safe, because germs cannot pass through clay.

Dangers from Rope and Bucket. The model well is fitted with a pump. This delivers the water into the bucket in a pure state. If the water is drawn with a rope and bucket, the drippings from the hands fall into the bucket. From what you have learned about typhoid fever you can readily see how easy it would be for a person nursing a case of typhoid fever to transfer the germs from the hands to the water.

Spring Water. This is not a safe water supply if we take it year in and year out. A spring gets its supply of water from the surface also, but is not usually dangerous if it is protected so that no water can get in except through the fountain head of the spring. A spring should have a concrete curb around it to keep water from the near-by surface from draining into it. If a spring is on the downhill side of a house, it is dangerous, especially if it has not a watertight curb or rim around it.

River Water. This is the main source of the water of most of our cities, and it is usually so dangerous that it must be treated in some way before it is safe to use at all. It is easy to see that many filthy things get into a river, and were it not for the purifying action of the sunlight and air, and the filtering of the sand, river water would be entirely unusable. River water is especially dangerous just below a city or town. Some cities keep an account of all cases of illness that occur along the banks of the river for miles and miles above the pipe which takes in their water supply from the river.

In case of an epidemic of typhoid in any city or town, it is well to ask your local health officer about the water supply. As far as communicable diseases are concerned, all water may be made safe for drinking by boiling. The taste may be restored to boiled water by pouring it through the air from one vessel to another.

Deep Well Water. This is absolutely safe, provided no surface water can leak in from the top. If the casing is watertight, no leakage can occur. The casing is usually made of iron pipe.

Importance of Water Supply of Summer Camps. The pleasant climate of Texas, and the excellent facilities for enjoying camp life, entice many campers out into the groves and prairies each year. It is not at all uncommon for these campers to contract typhoid fever while on their vacation, and as the fever requires two weeks to develop, these attacks of fever usually come on after the campers

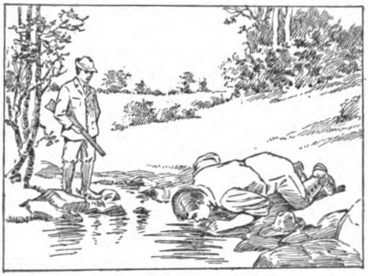


Figure 64. — Boys out hunting should not drink from streams.

have returned to the town or city. We should learn from this the necessity for being careful about selecting drinking water even when out for a few days' trip. The picture shows a lad drinking from a brook. Streams are often poisoned by the germs that have washed into them from the premises of farmers up the stream.

Contamination after Water is Drawn. Even if we have a good water supply, bacteria may get into the water after it is drawn, unless we take certain precautions in the handling of it. The public drinking cup is a great danger. You have learned that the secretions from our bodies are likely to contain the bacteria which cause disease. Each time that we put a drinking cup to our mouth, some of the saliva that has dried on our lips is removed by the cup. Needless to say, any germs that are in our system are likely to be spread in this way. We have every reason to believe that the germs of diphtheria, tuberculosis, typhoid fever, and other dangerous diseases have been distributed by the public drinking cup. (See Sanitary Code, Rule 61.)

How to Make a Sanitary Drinking Cup. This is shown in Figure 65. In making these cups, use a clean sheet of paper, and do not put the fingers inside to pull the cup open after it is made.

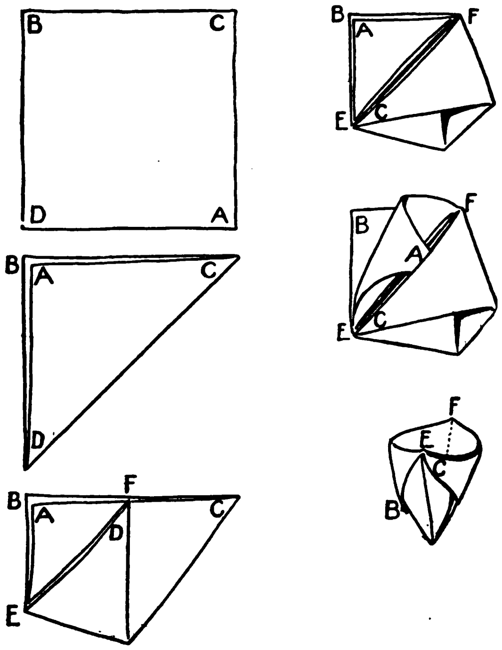


Figure 65. — This picture shows how to make a sanitary drinking cup.

The Sanitary Drinking Fountain. In public places the sanitary fountain is coming to be used. One of these is shown in Figure 66. Before drinking from such a fountain, a person should make sure that the water is spurting up high enough to enable one to drink without touching the lips to the metal or rubber mouthpiece of the fountain itself. If the lips touch the mouthpiece, an exchange of germs might take place which would defeat the object of the sanitary fountain.

Typhoid Fever. This is without doubt the disease we should think of when we study the water supply. We should not, however, forget that the fly may cause as much typhoid fever in Texas as the drinking water. You

Figure 66. — Sanitary fountain in one of the Houston schools.

have learned on another page how to tell whether a given epidemic is due to drinking water. In towns, if the epidemic is due to water, it is likely that a great many persons will be affected at the same time, and all parts of the town using water from the same source will be equally affected. If the epidemic comes up in springtime, and grows gradually worse as the summer wears on and as the flies increase, it is not likely to be due to the water. It is more likely to be due to the fly, especially if certain unsanitary parts of the town are affected more than others.

Asiatic Cholera. This disease is spread by drinking water also, but is not likely to attack us. It has been almost stamped out in the greater part of the civilized world.

Other Diseases Spread by Water. *Hookworm disease* may be spread to some extent by drinking water, and this is probably the case in the older parts of the state, especially in the sandy regions. *Amebic dysentery* is spread by drinking water, but there is not a great deal of it in Texas. It is likely to be brought in at any time from Mexico, but it is not an epidemic disease.

All Typhoid Germs Come from the Bodies of the Sick. Probably the most important thing to remember in connection with the spread of disease by drinking water, is the fact that the germs have to originate in the body of some one sick with typhoid or other disease. If the germs are not poured out on the ground, they cannot be washed into the well or river. *The best place to attack a disease is in the sick room, and the best method of attacking it is to disinfect all body wastes so that the germs are done away with forever.* You will learn in Chapter XIX how to disinfect. When we disinfect the body wastes, we are heading the germs off from our drinking water.

IMPORTANT POINTS

1. It is not the chemical or mineral contents of water, but the bacteria, which make it unsafe.

2. Water may be clear and palatable and yet be dangerous.

3. Cistern water may be contaminated by bacteria carried to the roof by pigeons and sparrows, or it may be contaminated by surface water which overflows or leaks into the underground cistern; owing, however, to the mosquitoes which breed in them, cisterns are concerned more in the spread of malaria than in the spread of typhoid.

4. The shallow well is dangerous, but it can be made a reasonably safe source of drinking water by observing the situation of the well, by casing it in and covering it properly, and by having a pump to raise the water.

5. River water is risky and usually has to be treated by filtration when used as a public water supply; in time of an

epidemic in towns and cities the water should be boiled before it is used.

6. A deep well, when properly cased in, supplies a perfectly pure water.

7. Bacteria are frequently introduced into drinking water after it leaves the well, as for instance by the public drinking cup.

8. Typhoid fever is the disease which drinking water most often spreads, although this disease is spread in other ways also.

QUESTIONS

1. Why must we be careful in selecting drinking water? 2. Of all diseases spread in Texas by drinking water, which one causes the most deaths? 3. Do you understand this to mean that water is the only cause, or the most important cause of the spread of this disease? 4. What are the dangers of the uncovered cistern? 5. What is the object of casing the well in, and how should this be done? 6. Why is a pump safer than a bucket and rope? 7. What is the object of having a watertight platform or cover for the well? 8. Why should the earth be piled up around the well? 9. What diseases can be spread by the public drinking cup? 10. What is the danger in placing one's mouth over the outlet of a sanitary fountain before the water begins to flow? 11. Fold a sanitary drinking cup. 12. Where do the disease germs come from that are in drinking water? 13. Where is the best place to kill these germs?

CHAPTER XIX. DISINFECTION, OR HOW TO KILL BACTERIA

In this chapter we shall learn how to kill bacteria in various ways. They are easy to kill if one knows how, but they are not all alike, and what will kill one variety of bacterium may not kill another. So the question is an important one to study. Remedies that kill germs, or prevent them from multiplying, are called *germicides*, *disinfectants*, or *antiseptics*.

Sunlight and Fresh Air. These kill germs better than any other remedies. Wherever we can get a supply of bright sunlight, we shall not have many germs. There are some things, however, that we need to notice about

Figure 67. — Sunlight is a good disinfectant.

the action of the sun on bacteria; for instance, the sun must shine directly on and against the body of the bacterium before it can kill it. If you place some tuberculosis germs in a thin layer on a pane of glass, and then put this in the sunlight, the germs will be dead in a few hours. But if you throw the germs on the ground, some of them will remain on top of the ground and can be readily reached and killed by the sunlight, while others may sift down into the dirt so that the sun cannot shine upon them. These will not be killed by sunlight. In dark corners, inside the house, the germs of tuberculosis can live for months.

Soap and Water. Next to sunshine, soap and water are the best disinfectants for everyday use. If we use plenty of water and plenty of good soap, the skin will be kept almost free of germs. If we keep the hands clean, we shall escape those diseases spread by fingers, such as typhoid fever.

Figure 68. — Soap and water, another good disinfectant.

Difficulties of Disinfection. But there are times when we wish to destroy all germs in a certain place, and to do it at once. In these cases we can use heat, or we can use certain powerful chemicals or drugs. These disinfectants are powerful enough to kill any germ, and, if they are not used properly they may kill human beings. Germs are to a certain extent like human beings, because they are living;

and whatever tends to kill the germ, might also tend to kill the human being. This will make clear to you the difficulty of killing germs when they are in our bodies. Unfortunately, we have no chemical that will kill the tuberculosis germ in the human body without injuring the body itself.

Boiling Kills Germs. In case the bacteria we wish to kill are not in the human body, our task is much easier. Boiling will kill any bacterium known. One minute's boiling will kill almost all bacteria. There are certain bacteria, however, which can withstand boiling for several minutes. These bacteria are encased in a hard shell in which they are safely shut up like a turtle in its shell. It is only certain kinds of bacteria that form these shells, and we call the bacterium with its shell around the outside, a *spore*. The tetanus or lockjaw germ, and the germ of anthrax or charbon, which attacks cattle, are two germs which form spores. You will see that our worst diseases, such as tuberculosis and typhoid fever, are caused by germs that are very easy to kill, when we can get at them. The meningitis germ is very easy to kill.

Chemical Disinfectants. It is not always convenient to boil things, and there are certain chemical disinfectants that will kill germs just as certainly as heat. Probably carbolic acid is the commonest one of these. A solution of carbolic acid, made by adding one tablespoonful of the acid to a quart of water, will kill any one of the germs, except the spore-forming ones, in five minutes. This is a strong solution, and yet it takes five long minutes to kill the germs. A mistaken idea exists that a saucer of carbolic acid placed under the bed will disinfect the entire room.

Some people believe that by removing bad odors they disinfect a room. Some even go so far as to believe it is sufficient to cover up these bad odors with other stronger ones. This is not only useless, but it is dangerous, because it gives a sense of false security or safety. In the toilet rooms of many public buildings, hotels and the like, are to be found little metal cylinders which give off a peculiar odor. These do not destroy disease germs. It would be just as sensible for us to use perfume instead of bathing as it is to place these strong-smelling cylinders in our buildings. Another mistake is that of confusing disinfectants with insecticides. Some remedies are sure death to insects but harmless to germs; some remedies which kill germs do not harm insects. The gasoline mixtures which do such good service as insecticides are usually ineffective as disinfectants.

The following table shows how the various disinfectants should be diluted for use, and tells which are most effective. All things considered, the coal-tar disinfectants are the most effective and the cheapest. There are several of these preparations on the market, and the State Bacteriologist has prepared a list giving the exact strength of each. This list will be furnished upon request to the State Board of Health at Austin.

In buying a disinfectant, always take into consideration how much diluting is required. It is best to rely upon reports made by the Marine Hospital service at Washington or the State Board of Health at Austin, as to the strength of a given disinfectant. Of two disinfectants at the same price, buy the one of the greater strength, which will require greater dilution and go farther.

Fumigation. So far, the chemical disinfectants mentioned are useful only when we can place the thing to be disinfected in the solution. But when we come to disinfect an entire room, as for instance when we move into a rented house, we cannot do this, and so we have to use a gaseous disinfectant, such as formaldehyd. The formaldehyd method of disinfecting a room is very effective, is not difficult, and does not damage any of the furnishings usually found in a living room. The following directions

TABLE SHOWING HOW LONG IT TAKES CERTAIN DISINFECTANTS OF GIVEN STRENGTH TO DESTROY GERMS

NAME OF DISINFECTANT	NAME OF GERM	HOW TO MAKE SOLUTION	LENGTH OF TIME NEEDED TO DESTROY GERMS MENTIONED
Boric Acid	Typhoid	All that will dissolve in water	Does not destroy all of the germs even in a week's time
Boric Acid	Pus Germs	All that will dissolve in water	Has very little effect on germs
Carbolic Acid	Typhoid	Tablespoonful to quart of water	Five minutes
Carbolic Acid	Pus Germs	Tablespoonful to quart of water	Five minutes
Carbolic Acid	Anthrax Spores	Two tablespoonfuls to pint of water	Spores live four to forty-five minutes
Corrosive Sublimate; Bichlorid of Mercury	Typhoid	Three grains to pint of water	Five minutes
Corrosive Sublimate; Bichlorid of Mercury	Pus Germs	Seven grains to pint of water	Five minutes
Corrosive Sublimate; Bichlorid of Mercury	Anthrax Spores	Three grains to pint of water	Twenty-six hours
Coal-tar disinfectants	Typhoid	Teaspoonful to pint of water	From one-half to five minutes

are taken from the book of instructions of the Texas State Board of Health:

To fumigate an average-sized room the only utensils needed are an old three-gallon scrub bucket made of zinc (not wood), and three bricks. Secure from the drug store

$13\frac{1}{2}$ ounces of potassium permanganate and a quart of formaldehyd. Place the bricks in the center of the room on the carpet or the floor, and the bucket on the bricks. Close the doors and windows tight and place strips of wet paper over all cracks and openings. It is a good plan to stretch all linen, quilts, etc., on a line so as to expose as much surface as possible to the disinfectant gas. They should not be thrown in a heap. Put the permanganate

Figure 69. — Fumigating a room in a rent house. This should always be done except in a house that is new, or one in which the family moving out were in perfect health.

into the bucket and pour the formaldehyd over it. Leave the room at once, closing the door tightly, and do not open the room for at least six hours. (See also Sanitary Code for Texas, Rules 55–60.)

Mixed Disinfectants Are Not Good. It is almost always unwise to mix disinfectants, because when two disinfectants are mixed, the resulting mixture does not usually possess a disinfectant value equal to the sum of the disinfectant values of the two ingredients. For this reason the patented antiseptic solutions alleged to contain boric acid and several other antiseptic substances are often expensive and inefficient.

IMPORTANT POINTS

1. Soap and water and sunshine have a great influence on your daily life. Keeping your hands clean and cleansing them especially before eating, is a health-saving habit for you to form.

2. It takes strong chemicals and a considerable length of time to kill bacteria, hence we should not rely upon any disinfectants except those approved by the proper authorities.

3. Every family should fumigate or disinfect a house before moving into it, unless they know something of the history of the house and its occupants for the previous twelve months.

QUESTIONS

1. Name three ways of killing germs. 2. Is it easy to kill germs in the human body? 3. How long can disease germs live in boiling water? 4. What are spores? 5. Name one disease germ that forms spores. 6. What two things are of importance in killing germs with carbolic acid in water? 7. When should we disinfect a room by fumigation?

CHAPTER XX. KEEPING ACCOUNT OF OUR TREASURE

What is the most valuable thing on earth? Some of you may answer friendship, gold, radium, platinum, diamonds. There is one thing, however, which we must have before we can use or enjoy any of these things, and that is life itself; the most valuable thing in the world, then, is human life.

Bookkeeping. Every merchant keeps a set of books showing the money he takes in and pays out. He does this because the money is worth a great deal. Every civilized government keeps a set of books dealing with lives, as well as dollars. This set of books shows the number of lives received each day, or, in other words, the

1911 VITAL		STATISTICS	
TUBERCULOSIS	3137	PNEUMONIA	1756
TYPHOID	992	MENINGITIS	259
MALARIA	349	GRIP	133
DIPHTHERIA	289	WHOOPING COUGH	120
MEASLES	222	TETANUS	86
SCARLET FEVER	105	SMALLPOX	47

Figure 70. — These figures show the deaths from certain preventable diseases in Texas during 1911.

number of babies born. It shows also the number of lives paid out each day, and what they were paid out for; that is, the number of deaths and by what the deaths were caused. If a merchant finds that he is paying out a great deal of money for coal, he will try to find some way to stop the expense, because money is valuable to him. If the government finds it is paying out a great many lives each day on account of typhoid fever, for example, the government will try to stop the disease, because the lives are valuable. Now, this set of books kept by the government we call *Vital Statistics*.

Usefulness of Vital Statistics. There is no use in keeping this list of deaths unless it is studied with a view to saving life. On the other hand, it is hard to try to save people from sickness unless there is a list showing which diseases are killing the most people. Suppose the pupils in your school wished to help in the prevention of disease and started in by studying the plague. There has not been a case of plague in Texas, however, for many years; probably there has never been any here. You could not help Texas people much in that direction, could you? But by observing the records of vital statistics you will see that typhoid fever kills a hundred people or more in Texas each month; you might, then, do some good by trying to prevent typhoid fever. After you had been at work a year or two, and found that typhoid was killing only fifty people in a month, you would feel that you were going at the business of life-saving in the right way, would you not? It would be foolish to try to prevent disease without keeping a complete record, so as to see where prevention was needed, and to see whether your attempts at prevention were a success.

Other Purposes of Vital Statistics. It has been found that vital statistics can be made to serve other good purposes besides protecting the public health. The official records of births and deaths, for instance, are useful in settling disputes as to age and inheritance. Most states which have a system of vital statistics require a death certificate to be signed and filed with the proper officer before allowing a burial to take place. Murderers and poisoners find it impossible to get a death certificate signed for their victims, because there is no physician who knows the cause of death, and hence the body of the victim of the crime cannot be buried legally. When the murderer tries to get a physician to sign the certificate, or tries secretly to bury the body of the victim, he is frequently detected and brought to justice.

Death Certificates. It has been found most practical to require the undertaker to fill out and prepare the death certificate, for the physician rarely goes back to the house after a person is dead. The undertaker always has dealings with the family just after the death occurs, and hence he is best situated to get the information required on the death certificate. The physician, however, is the only person to pass on the question of the cause of death, and so the law in Texas requires him to sign the death certificate, giving the cause of death. The report of the death is filed with the city physician in case the death occurs in a town or city; if it occurs in the country, or outside of an incorporated town, the report of the death is sent by the undertaker to the county clerk. The officer who first receives the death report sends it to the State Registrar of Vital Statistics at Austin, and once each month the State Registrar publishes a statement of the causes of all deaths reported during the month. (Study in this connection the Sanitary Code for Texas, Rules 34–50.)

Texas Statistics. Not much more than half of the United States preserves complete and accurate vital statistics. In the thinly settled parts of the country it is hard to get the deaths and births reported. Texas has not yet succeeded in getting complete reports of all its deaths, but it has been making rapid improvements in this regard, and no doubt will have a complete set of returns before a great while. We cannot compare our Texas vital statistics with those of other parts of the United States without making certain changes to make up for the incompleteness of our reports. But we can make these changes and in that way, with a fair degree of accuracy, compare our health conditions with the conditions in other states.

Comparison of Texas with Other States. We will begin by assuming that Texas has about the same annual death rate as Indiana, or 13.5 per thousand. In order to make comparison easy, it is customary for all death rates to be calculated on a basis of so many per thousand inhabitants, or so many per hundred thousand inhabitants. When this is done, it saves us the trouble of taking into account the number of inhabitants of each place. The following table shows the death rates of several states from some of the prevalent diseases. The figures from the United States as a whole are given in order to give us an idea of the average death rate over the entire country. The rates from Massachusetts are given because this is an old and thickly settled state and has an especially good set of health laws. The rate from Indiana is given because this state is largely agricultural, like Texas, and hence the conditions in the two states are more or less similar.

The first column of figures in the table refers to the annual death rate per thousand of population; all the other columns refer to the annual death rate per hundred thousand of population.

	All Causes	Typhoid Fever	Tuberculosis	Measles	Scarlet Fever	Small-pox
United States	15.0	23.5	139.7	12.3	11.6	0.4
Massachusetts	16.1	12.4	137.6	11.6	8.0	0.0
Indiana	13.5	34.0	144.9	16.6	7.5	0.1
Texas	13.5	48.3	136.1	4.6	1.9	2.0
Paris, France	16.7	7.0				

From this table we learn that Texas makes a favorable showing so far as the more contagious diseases are concerned, but makes a very poor showing in the case of typhoid fever. In proportion to her population, Texas loses almost four times as many citizens from typhoid fever as Massachusetts, over twice as many as the United States as a whole, and over six times as many as Paris, France.

IMPORTANT POINTS

1. A good system of vital statistics is necessary as the first step toward intelligently attempting to improve the public health.

2. Our Texas system is not perfect, but is very valuable, and we should make every effort to improve it.

3. It can easily be seen that we have in Texas more than our share of typhoid fever.

QUESTIONS

1. What are vital statistics? 2. Why do we keep accounts of births and deaths? 3. Have we valuable statistics of deaths in Texas? 4. Are they perfect? 5. Who should report deaths? 6. To whom should he report them? 7. Compare the death rate from typhoid fever in Texas with that in Massachusetts. 8. Compare the death rate from measles in Texas with that in Massachusetts or Indiana. 9. Consult the table of vital statistics, but do not memorize it.

CHAPTER XXI. THE BODY A HOUSE OF MANY PARTS

Up to this time you have learned of the microscopic bacteria which sometimes invade the body in countless swarms, and you have learned that some of them tend to destroy our health by the poisons they give

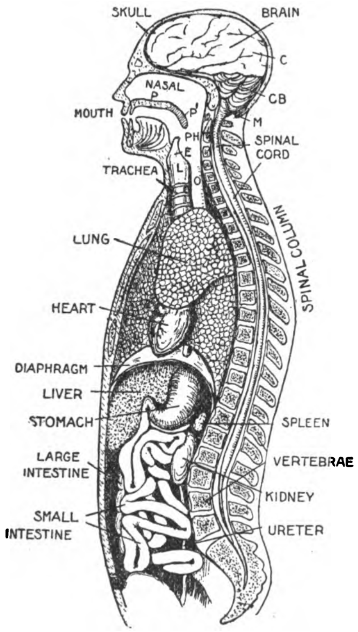


Figure 71. — Diagram of a section through the body to show the location of the principal organs.

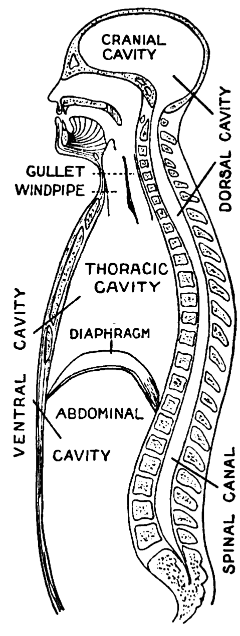


Figure 72. — Diagram showing the principal cavities of the body.

off into the blood. It is truly wonderful how our bodies can defend themselves against their enemies, the germs of disease, in the ways described in the preceding pages. We shall now learn many other wonderful things that the various organs of the human body have to do. We shall study the *physiology* of the organs; that is, their functions or duties, and how these are performed. To understand their functions we must first learn the structure of the organs; this study is called *anatomy*. After we have learned the function and the structure of an organ or a system of organs, we shall be told how to keep the organs in a condition favorable for doing their duty properly. The last study is called *hygiene*, or the science of health.

REVIEW AND OBSERVATION WORK. Review Chapter I; draw an outline sketch of Figure 73, and in the drawing name the organs mentioned in the chapter. Secure a manikin or model of the human body, and with the aid of this, study the organs.

Organs. From the study of the figures you are led to conclude that an organ is *a particular part of the body;* and when you recall what you already know of the work of the organs, like the heart, you will come to the conclusion that each organ has *a particular duty to perform.* Thus, the heart is an organ that pumps blood. Mention some other organs and tell what you think their duties are. Now, define *organ* in your own words.

The situation of the chief organs of the body may be learned by a study of Figures 71, 72, and 73. The word *dorsal* is the scientific term for the back and *ventral* for the front of the human body. *Dorsal* and *ventral* are also used in speaking of the corresponding regions of the bodies of animals.

The brain and the spinal cord are seen to occupy the *dorsal cavity.* The *ventral cavity* is separated by a partition, called the diaphragm, into the *thoracic* and the *abdominal cavities.* Above this partition are the heart, which pumps the blood, and the lungs, with which we breathe. Below the diaphragm are the organs of digestion, the organs of excretion, and others.

Finer Structure of the Organs. Each organ is composed of parts called *tissues.* There are different kinds of tissues, and each kind has a particular work to do in the organ. Take, for example, a piece of beef. The soft red part is *muscle tissue;* it is the main tissue that goes to make up the organs called muscles. Its work is to contract and expand, and thus cause motion.

Muscle tissue is very tender, however, and would not **hold** together by itself. The tissue that binds muscle

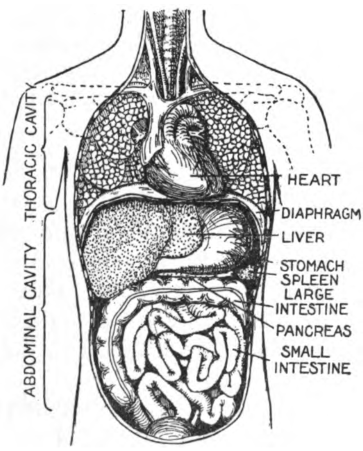


Figure 73. — Ventral view of the principal organs in the thoracic and abdominal cavities.

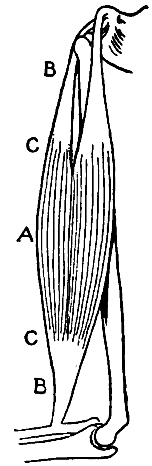


Figure 74. — A muscle.

tissue together is tough and pliable, and is found in all muscles; it is called *connective tissue.* This may be seen as glistening white strands in beef or other lean meat. It also serves to bind muscles to bones and bones to each other. The sinews or leaders in the legs of deer were used by the Indians for bow-strings on account of their toughness, for they consist of connective tissue. In the muscle shown in Figure 74 the part at *B* consists mainly of connective tissue; at *A*, mainly of muscle tissue; at *C*, of about equal quantities of each.

Other white strands often seen in a piece of meat are nerves, which consist of *nerve tissue*. Thus a muscle is an organ consisting of muscle tissue, connective tissue, nerve tissue, and other tissues not so easily seen.

Observation Work. Secure a piece of soup meat or other tough meat from around a bone, and let several pupils each take a small piece and dissect it. To do this, lay the specimen on a board or an old newspaper and pick it to pieces with a knife or sharp sticks. How many kinds of tissue can you find? Let all the pupils see them. Describe the kinds of tissue that can readily be seen.

Cells. Our study does not end here, however. With the unaided eye we cannot find out anything more about

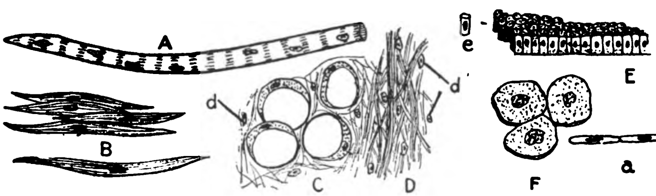


Figure 75.—Different kinds of cells: *A* and *B*, muscle cells; *C*, fat cells; *D*, connective tissue cells; *E* and *F*, epithelial cells; *e*, a single cell; *a*, end view of flat cells.

the tissues; but with the aid of the microscope men have been able to discover that the tissues are themselves composed of very tiny parts called *cells*. A number of cells are shown in Figure 75. Muscle cells are long and slender. One kind of muscle cell, shown at *A*, Figure 75, is very long and extremely slender; the other kind is spindle-shaped and shorter (*B*). A very long cell, like a muscle cell, is often called a *fiber*. Connective tissue consists of long fiberlike strands and scattered rounded cells (*D*). A collection of connective tissue cells filled with fat, as at *C*, is called *fatty* tissue.

Epithelial tissue is another important kind of tissue. In this the cells are shaped rather like grains of rice or corn, or are flat and thin like shingles. They stand or lie side by side, like the bricks of a pavement, and cover surfaces. For this reason the tissue is sometimes called pavement tissue. The skin consists of connective tissue covered over with epithelial tissue. Flat cells, like those pictured at *F*, can be scraped from the lining of the cheek and studied under the microscope.

OBSERVATION WORK. To get an idea of what a fiber looks like, take a sheet of good smooth writing paper. Tear off a corner and examine the torn edge, holding it between the eye and the light. The frazzled edge shows tiny fibers similar to the fibers of muscle and connective tissue.

Again, if each tiny cell is studied carefully under the microscope, it is found to consist of definite parts. These parts are (1) the body of the cell, and within that (2) a denser portion, the *nucleus*, as shown in Figure 76.

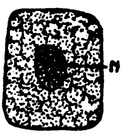


Figure 76.— A cell, showing nucleus.

The body is thus a colony of cells and may be compared to a brick building made up of an immense number of individual bricks. Just as from a distance we cannot distinguish the individual bricks of a house, so also we cannot distinguish the cells of the body, until we examine its tissues with the aid of a microscope. Without this instrument we should still be ignorant of much that we now know of the wonderful structure and work of our bodies.

SUMMARY

The body consists of myriads of tiny cells that cannot be seen without the aid of a microscope. Cells are of different kinds; a collection of similar cells is called a tissue. Tissues are combined to form organs. Each tissue has a particular duty to perform in the organ: muscle tissue to contract and expand and thus move the body, connective tissue to bind parts together, epithelial tissue to cover surfaces. Other kinds of tissues will be studied in later chapters.

QUESTIONS

1. When I say, "The heart pumps blood," does the statement concern the physiology or the anatomy of the heart? 2. What is meant by Physiology? 3. Anatomy? 4. Hygiene? 5. Sanitation? 6. What is an organ? 7. Name the cavities of the body. 8. Name and locate the important organs of the body shown in Figures 71 and 73. 9. Tell how the microscope has been of service to mankind. 10. Describe muscle tissue; connective tissue; a cell. 11. Draw pictures of several kinds of cells.

CHAPTER XXII. WHY WE EAT

All Animals Need Food. Have you ever observed a mother bird feeding her little ones in her nest? How wide the young birds open their hungry mouths while the devoted mother brings one worm, insect, or seed after another to appease their appetites! All animals must have food. You who eat your daily meals with regularity have perhaps not thought of the way animals have to struggle for a living. Consider how the following animals secure their food: cats, wolves, deer, fish, birds, spiders, boll weevils, mosquitoes, bees, owls. Discuss them in class.

A large part of an animal's time is spent in securing food. The same is true of man. In order that you may eat, the food for you is secured by your parents or guardians. They supply you with food while you are in school in order that you may learn useful things, which will better enable you later to earn your bread for yourself. A reference to your textbook of geography will show you what a large part of man's time is spent in raising, distributing, and selling plants and animals for food.

Why we Need Food. When asked why we need food, different persons give different answers. "To nourish the body," "To give us strength," "To keep us alive," are among the answers often given. Perhaps we may find more simple answers to the question why we eat.

If, in the first place, you consider that you must feed your horse more when he works than when he is idle and that you are usually hungry after vigorous exercise, you must come to the conclusion that food has something to do with our power to work. We may answer the question why we eat by saying first, that *food furnishes us with energy for work.*

You have also noticed another thing about the living body; namely, that it is always warm. Food is used up in the body all the time. It is the source of heat as well as of energy for work in the body. We need food, in the second place, *for warmth.*

To make clear just how food furnishes us energy and heat, the body has been compared to an engine. Let us take for example a steam engine, under the boiler of which wood is burned to get up steam. It is plain that the energy that makes the engine run comes from the wood that is burned under the boiler. Before we explain just what happens to the wood when it burns, it will be well for you to perform the following experiment:

EXPERIMENT WITH CARBON. You have all seen carbon in the form of charcoal or of coal. You are also acquainted with it in the form of graphite, the so called lead of your pencil. Strike a match and let it burn until it is well scorched. The black you now see is carbon that has separated out from the wood and that has not yet burned. Now light another match and let it burn. Note that it becomes smaller and smaller; the match is being used up. Note the current of air passing off from the flame. Something is passing off from the burning match into the air. In burning, then, the fuel is used up and matter is given off into the air. Strike a third match and hold it in a small bottle. It will soon go out for want of air.

In the process of burning, as was noted in the experiment just performed, two things are needed: fuel and air. In the case of the fire under the boiler of the engine, fuel and a draft of air into the furnace of the boiler are both necessary for the fire. Now, air contains a gas called oxygen (O). It is this oxygen that takes part in the burning. It does so by uniting with the carbon (C) of the fuel and forming a new substance, carbon dioxid (CO_2). This is also a gas, and passes off into the air with the smoke. Burning is, therefore, sometimes spoken of as *oxidation*. Oxidation results in forming carbon dioxid as a waste substance and, most important of all, in giving off heat in the process.

The same thing happens in the body-engine. Food is the fuel of the body. Oxygen is taken from the air we breathe. Oxidation of the foods takes place in the tissues of the body. By this process heat is produced and the body does work. Wastes are also produced, especially carbon dioxid. This gas is given off into the air breathed out by the lungs.

Can you tell why you must breathe faster when you exercise? Can you tell why you grow warmer from such exercise? It is plain, then, that *we must eat that our bodies may be supplied with energy for work and with heat to keep them warm.*

We also need food for other reasons. Consider that the nestling bird is small and featherless, the puppy is not nearly so large as the grown dog, and you are not as large as you expect to be. Young animals and boys and girls *eat to grow.* Not all the food is oxidized in the body, for some of it must be changed into flesh and blood and added to the growing body. In this respect the body differs from an engine made of iron and steel.

Our bodies differ from an engine in another respect. The engine cannot repair itself. If a part breaks or wears out, a new part must be supplied. Every part of the body is constantly wearing out, but the body repairs itself. In case of injury to the skin, new skin soon covers the wound. If a bone is broken, the pieces will grow together again. Hair and nails and skin, are continually growing to take the place of cells worn off. We need food, therefore, *to repair worn-out parts of the body.*

How Plants Serve Man. Plants are living things just as animals are, and they, too, need food. Plants, however, manufacture their food themselves out of mineral substances; whereas animals and man must make use of the starch and other substances prepared for them by the plants.

SUMMARY

Green plants manufacture foods for animals and man. This food furnishes energy, enabling us to move about in work and play and keeping our bodies warm. The food containing carbon will burn like wood or coal by uniting with oxygen from the air. Food also furnishes material for growth and for the repair of injured or worn-out parts of the body.

QUESTIONS

1. Make a list of the names of animals and place opposite each the name of the chief kind of food the animal lives on. 2. Name four reasons why we need food. 3. Do we need more food in winter or in summer? 4. Why do we need more food when we exercise than when we rest? 5. What kind of substance is carbon? 6. Name some substances that contain carbon. 7. What is the use of carbon in our foods? 8. What part do plants play in nature?

CHAPTER XXIII. WHAT WE EAT

All animals depend directly or indirectly upon green plants for food. Most animals live upon plants directly, as cattle, potato beetles, and plant lice. (Mention five others.) Some animals prey upon other animals, as wolves upon sheep and cats upon mice; but in each case the prey gets its food from green plants, and so the wolf and the cat are dependent indirectly upon plants. Man eats both plant and animal food. Do you know of animals that do the same? Consulting your geographies, make a list of five important animals used by man for food, and ten important plants. Tell where each of these is raised. Make a list of twenty-five food products that you can buy at the grocery store. These studies will show you that there are many kinds of food. Even the same animal may produce various kinds; cattle, for instance, furnish meat, milk, and cheese. *All food of man, therefore, comes from living things.*

All these kinds of food are really made up of five classes of food substances. That is, all the foods placed on the table before us to eat, or that we feed to our domestic animals, are mixtures of these classes: *carbohydrates*, *fats*, *proteins*, *mineral salts*, and *water*. These five classes of substances are called the *foodstuffs.*

The Carbohydrates. The carbohydrates include starch and the sugars. They come almost altogether from plants and are the cheapest of the foodstuffs. Starch is found in large quantities in most seeds, such as corn, rice, wheat, beans, and peas; in the stem of the sago palm (sago); in roots and underground stems of manioc (tapioca), in the tubers of the sweet potato and the Irish potato. Sugars are of different kinds: cane sugar, secured from sugar cane and sugar beet; and *glucose* or grape sugar, found naturally in grapes and other fruits, but also manufactured from cornstarch in large quantities. Cane sirup (molasses) and corn sirup contain chiefly sugar and water. Honey and the sap of maple trees are also sources of sugar. Sweet corn and milk and most fruits contain some sugar.

EXPERIMENT WITH STARCH. One can easily find out whether a substance contains starch or not. Iodin turns starch blue. Make a thin starch paste by boiling a little starch in water. Add one drop of tincture of iodin (to be secured from any drug store) to a little starch paste in a test-tube or a small bottle. Try this on crumbs of bread shaken up in water. Place a drop of the solution on a cooked potato; on a raw potato; on an apple, or on any other food you want to test for starch.

EXPERIMENT WITH SUGAR. If food is sweet, it contains either cane sugar or glucose. The latter is easily found if present, because it causes a red color to appear when heated with Fehling's solution. Fehling's solution is a mixture of two

Figure 77. — Showing two methods of heating liquids.

solutions: *A*, a solution of bluestone, and *B*, a solution of caustic soda. The solutions should be kept separate until they are used. They can be secured at the drug store and should be fresh. Glucose is found in corn sirup and cheap stick candy. Dissolve some of either in water. When ready to make the test, make up a quantity of Fehling's solution, by using equal parts of *A* and *B*. Pour the mixed solution into a test-tube to the depth of an inch. Bring it to a boil, using an alcohol lamp and applying the flame to the top of the liquid, as shown in Figure 77. Now add about fifteen drops of a solution of stick candy. The red color which will appear indicates glucose; for cane sugar will not cause the red color. Try this also on cheap cakes, to find out what kind of sugar was used in their manufacture.

EXPERIMENT TO SHOW HOW GLUCOSE IS MADE FROM STARCH. Add ten drops of ten per cent hydrochloric acid to thin starch paste in a test-tube (to the depth of one inch) and heat it for ten or fifteen minutes. Note that the liquid becomes clear. Test for sugar as in the last experiment. The acid has turned the starch into glucose.

Some Foods Rich in Fat. Animals produce fats in their bodies. Meat, therefore, contains more or less fat, such as tallow and lard. The cream of milk is fat; cheese, being made from milk, contains much fat. Nuts are usually rich in fat, as are also the seeds of the cotton plant and peanut and the fruit of the olive. There is not much oil in grain, but corn contains more than the other grains. A fat that is liquid at ordinary temperatures is called an *oil*. Thus cottonseed oil is an oil; tallow is a fat.

Some Foods Rich in Proteins. A few plants furnish food rich in protein, as for example peas, beans, and peanuts. Among the common grains, wheat contains the most protein, rice the least. The chief source of protein, however, is animal foods. The white of an egg, called *albumen*, is almost pure protein, as are also lean meat and the curd of milk.

Experiment with Protein. Shake up a very little white of egg in a test-tube with about twenty drops of water. Add ten drops of concentrated nitric acid and warm the mixture over an alcohol flame. A yellow color appears. Add ammonia until effervescence ceases. The orange color that appears indicates the presence of protein, — in this case, the white of egg. Try this on bread crumbs or other food.

Observations on Grains of Rice, Wheat, and Corn. Soak in water for twenty-four hours enough grains of rice, wheat, and Indian corn to supply one or two of each kind to each pupil in the class. If needed at once, the seed may be boiled for a short time. Note the germ or embryo (*E*) as shown in the outline sketches in Figure 78. With a sharp knife cut the grain lengthwise through the germs along the straight lines indicated in the drawings. Study the cut side; make out the germ in the corner and the protein and starch portions of the grain. The starch will be found white and softer than the more shiny and horny protein portion of the seed. What kind of corn is it more profitable to raise, corn with seeds rich in starch or corn with seeds rich in protein?

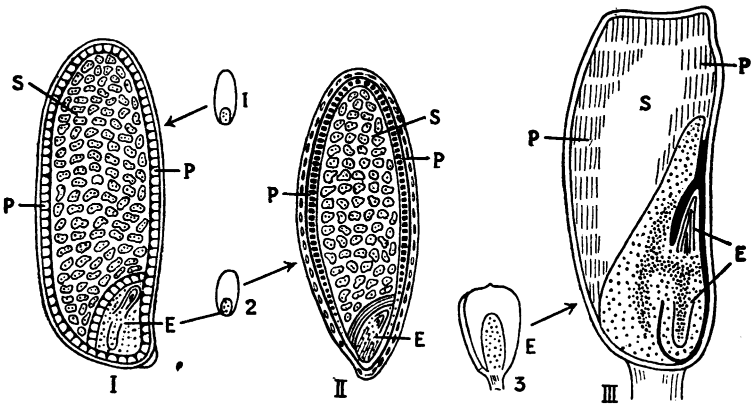


Figure 78. — Sections through seeds of rice (I), wheat (II), and corn (III), showing the protein (*P*) and the starch (*S*) of the seeds, and their germ (*E*); 1, 2, and 3, the seeds as seen from the outside, natural size.

Mineral Salts. All our food, even most drinking water, contains mineral salts. If we eat a variety of food we get all the mineral salts we need, except table salt, without adding them to the food in cooking.

Experiment. To show that foods contain mineral matter, take a piece of bread or meat, place it on a piece of tin, or

Figure 79. — When bread or other food is burned the ash or mineral part of the food is left.

better in an iron spoon (Fig. 79), and burn it over a fire. Examine the ashes. They are the mineral matter in the food.

Water. From one standpoint oxygen is the greatest need of the body, for we could live only a few minutes without breathing. Water comes next in importance; for while we may be able to live for forty days or more without food other than water, we cannot live much more than one fourth as long without water. Almost three fourths of the body is water. We not only drink water, but we get a great deal of it in our food. Over eighty per cent of potatoes, for example, and fifty per cent of beef consists of water.

EXPERIMENT. Weigh an apple or a potato. Then chop it up and dry it with slow, gentle heat. Now weigh it again and calculate the per cent of water in the food.

Uses of the Foodstuffs in the Body. In the last chapter it was stated that foods (1) furnish energy for heat and work and (2) furnish material for growth and repair. All the foodstuffs, except water and mineral salts, serve the first purpose, because they have carbon that burns up in the body.[1] The carbohydrates and fats can serve only to produce heat and energy and are therefore called the *fuel foods*. Proteins can serve this purpose also; but in addition to this they build up the body and repair the tissues. The proteins are therefore the only *building foods*. Some mineral salts help to build up the body to some extent, as lime to help form bone; but they are chiefly needed to keep all parts of the body in good working condition.

SUMMARY

There are many kinds of food that serve for man and beast the world over, some derived from plants and some from animals. These contain only five classes of foodstuffs: carbohydrates (sugars and starch), fats, proteins, mineral salts, and

[1] You may easily prove that there is carbon in protein and in starch and sugar by scorching them (in frying an egg or baking bread, for example). The black substance is carbon.

water. Carbohydrates and fats are called the fuel foods, since they serve only to be oxidized or burned in the body for the production of heat and energy. Fats are the best heat-producing foodstuffs. Proteins also are of use as a fuel food, but in addition they build up the tissues, being used in the body for growth and repair. Certain mineral salts and water must also be taken with the food for the maintenance of health.

QUESTIONS

1. Mention ten common foods. 2. Mention the main foodstuffs. 3. Are animal or vegetable foods the richer in carbohydrates? 4. Mention four foods rich in fats; six rich in protein; eight rich in carbohydrates. 5. How can you test a food to find out if it contains starch? 6. What is the test for protein? 7. Which foodstuff is the only tissue builder? 8. Why can all the foodstuffs furnish working energy and heat? 9. Which is the best fuel food? 10. Mention some important mineral salts. 11. How can you prove the presence of mineral in food?

CHAPTER XXIV. PURE FOOD

To select foods wisely we should remember several important things: what foodstuffs the foods contain, for whom they are intended, how to get the greatest food value at least expense, and we should see that all foods are free from disease germs.

A Mixed Diet. Every one knows that a person cannot live on eggs alone, and you now know that the reason is that eggs do not contain carbohydrates. All of you like

Figure 80. — Refrigerator: food should be kept cold to prevent decay.

candy; but you would soon grow tired of candy if you had nothing else to eat, and would ask for plain bread and butter and meat. It is not a good plan to live on any one kind of food. We need a mixed diet. As a rule, we need nine times as much carbohydrates as fats and twice as much protein as fats.

Starch and sugar are useful to furnish working energy and warmth. They should make up the bulk of what we eat. Protein is especially useful for building up our bodies, and growing children need plenty of protein food. One who is recovering from an illness needs much protein. Of fats we should eat more in cold weather than in warm, for the reason that fats are the best fuel foods.

Eating Habits. It is important for the health that one should eat regularly. Although eating between meals is a bad practise, a sandwich or the like on returning home from school may be permitted. Too often candy is indulged in between meals. Candy is harmless in moderate quantities, but it should be eaten at the end of the regular meal. Colored candy, however, is harmful in many cases.

A warning is also needed in the matter of school lunches. Many children buy candies and pastry instead of providing themselves with lunches consisting of good food. School lunches, as indeed all meals, should be eaten slowly and the food well chewed; children should not rush out on the playground and engage in violent exercise immediately after the meal.

The Cost of Foods. The foods that cost least per pound are not necessarily the cheapest; thus corn meal is cheaper than wheat flour, but it contains less protein. The costliest is not always the best, for oysters are costlier but have less food value than either cheese or round steak. In purchasing food, we must take into consideration the quantity and proportion of the foodstuffs as well as the price per pound. Peas and beans are very cheap and nutritious articles of food. It is necessary, also to take into consideration the individual tastes in the matter of selecting foods, as foods must be appetizing and must agree with a person to be of the greatest value.

Buying Food in the Market. The best way to buy food is to make a personal visit to the market. In this way one can secure the best of any kind of food and can find things that he would otherwise not think of. In buying always say, "Let me see it first."

If you are too busy to go to market and must order the food over the telephone, always inspect it as soon as it is received and return that which is not fresh and good. The market man will furnish just as good food as we ask

Figure 81. — Cooking is so important that the subject is taught in many schools.

for. There is plenty of good food material to be had in Texas, and if our housekeepers pay attention to the food as it is bought, they can get good food. In buying fish and meats especially, great care is necessary; also in buying fruits and vegetables. Think of the number of over-ripe tomatoes that are placed on the table in Texas in the course of a year. The only way to avoid this is by looking

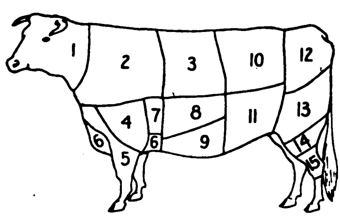


Figure 82. — The cuts of beef: 1, neck; 2, chuck; 3, ribs; 4, shoulder clod; 5, fore shank; 6, brisket; 7, cross ribs; 8, plate; 9, navel; 10, loin; 11, flank; 12, rump; 13, round; 14, second cut round; 15, hind shank.

at the tomatoes closely, and this should be done at the time they are bought. Those who are interested in marketing may learn the names of the cuts of beef from the numbered diagram (Fig. 82).

Canned Goods Canned fish and canned meats are dangerous, because a pinhole in the can, too small to be seen, may allow germs to get in and cause the decay of the meat. Canned vegetables are not dangerous as a rule but canned fish and canned meats are always subject to suspicion. A young man in Austin ate some canned salmon at three o'clock one afternoon and died of ptomain poisoning the next morning. Many people are thus made sick but do not die. Sometimes canned goods in putrefying form a gas which presses out the top and bottom of

Figure 83.—Swell head. Bacteria sometimes cause decay of canned foods, especially meats; the can may "swell" from gases on the inside.

the can, causing what is known as swell head (Fig. 83). It is unnecessary to say that such a can should be strictly avoided.

We should likewise reject old rusty cans. On opening the can, see if it is rusted on the inside; also taste and smell the contents and make sure that they have not begun to decay. Canned vegetables are more of a necessity in the North than they are here. Texas needs some progressive men to develop the various vegetable industries, just as the onion industry has been developed in and around Laredo.

Ptomain Poisoning Through ignorance and carelessness in selecting food, more serious consequences may result than mere loss of food. We sometimes poison people by giving them poisoned food. Have you not heard of the dreadful ptomain poisoning which kills so many people, especially after they have eaten fish? Many cases of ptomain poisoning could have been prevented by a little care in inspecting the fish when it was bought. Many of you may say that you do not know how to tell good fish or meat when you see it. But if you try, you will find that you can do so. There is a fresh fishy odor about all fresh fish, but there is a putrid odor, an odor of decay, which comes from decaying fish.

Another source of poisoning is ice-cream. When once allowed to melt, ice-cream should never be refrozen.

Cooking. Most foods are improved by cooking (baking, boiling, broiling, stewing, etc.) for the following reasons:

Figure 84. — A trichina from a muscle.

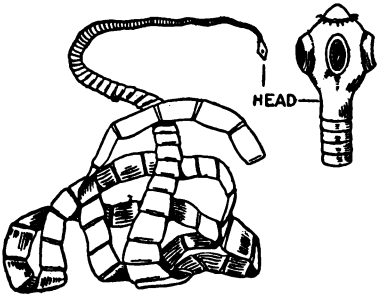


Figure 85. — Portions of a tapeworm with its "head" enlarged.

1. *Heat may destroy the bacteria.* Bacteria you know are likely to be present in food, but heat does not always destroy the poisons or toxins formed by bacteria in decayed or decaying food. Heat also destroys certain worm parasites, like trichina in pork (Fig. 84), or tapeworm larvæ in pork and beef (Fig. 85).

2. *Cooking makes most foods more appetizing.* Appetizing appearance and pleasant flavor in foods are important aids to digestion.

3. *Cooking usually renders foods more easily digestible.* In the case of vegetable foods we find that the plant cells have very thick and indigestible walls, and that the starch and protein grains (Fig. 86) have tough skins around them. Heat breaks up the starch grains and the plant cells (Fig. 86), so that the digestive juices can get to the food material. In the case of meats, heat causes the connective tissue to swell and soften, thus making it easy for the muscle tissue to be broken apart.

It should be remembered that heat hardens such proteins as muscle tissue and the white of eggs and makes

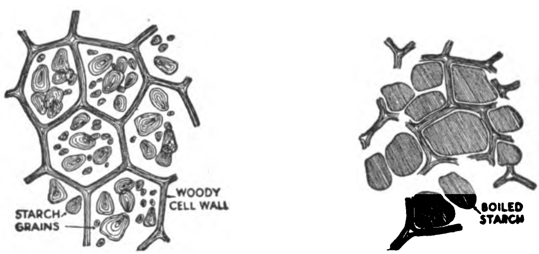


Figure 86. — Uncooked and cooked potato cells, magnified.

them harder to digest. White of eggs is more easily digested soft boiled than hard boiled. It is important to note that grease renders foods less digestible. Frying in grease is the worst way to cook. The grease soaks into the mass of the food, covering the minute particles so that these become very hard to digest.

Milk as a Food. Milk is one of the most nourishing of all foods. Cow's milk is the milk commonly sold on the market, and it forms an especially large part of the food of young children, old people, and invalids. When intended for babies under two years old, milk should be prepared by adding certain foodstuffs to it to make the proportions exactly right; that is, the same as those of human milk. This should be done under the advice of a physician. Babies usually do better on cow's milk than on patented baby foods when these are fed alone. Since, then, milk is so important as a food, we ought to see to it that our milk supply is clean and pure.

Bacteria in Milk. Because milk is very nourishing, bacteria will thrive and multiply in it. There are still a few dishonest people who add preservatives to milk; but the most dangerous things we find in the milk are the

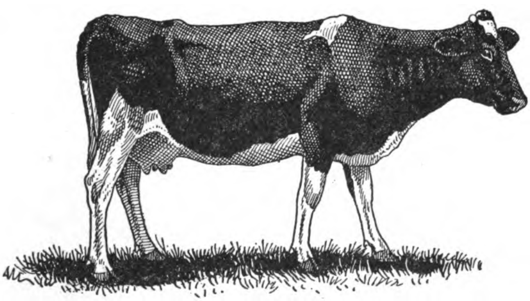


Figure 87.—This cow, though healthy in appearance, was found to have tuberculosis.

harmful bacteria. More epidemics of disease have been spread by milk than by any other food Hundreds of different outbreaks of disease have been definitely traced to germs scattered in milk. Most of these epidemics were of typhoid fever, but scarlet fever and diphtheria also have occurred in epidemic form because of the presence of disease germs in milk. Milk is especially connected with tuberculosis, because cattle are affected by that disease, and tuberculosis is one of the commonest diseases in the world. In view of these facts it is well to learn how milk can be kept free from dangerous germs.

How to Get Clean Milk: the Cow. First, the cow herself must be healthy. In many states, one fourth of all milch cows are affected with tuberculosis. In Texas, however, the tests made by the Dairy and Food Commissioner show that only one cow in about one hundred is affected. Children can contract bone and gland tuberculosis from germs in milk, and hence they should never drink milk from cows that have not been tested and found to be free from tuberculosis. The most healthy-looking cow may have the disease. Figure 87 shows a cow in apparently good condition, but when tested she was found to have tuberculosis.

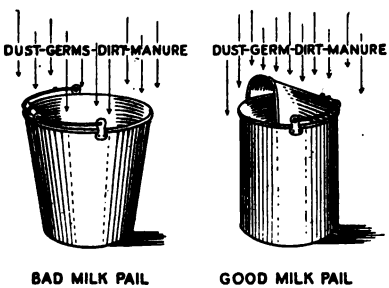


Figure 88. — A bad and a good kind of milk pail.

Milking. In milking we should do all we can to prevent bacteria from getting into the milk. If carelessly handled, especially about the cowsheds, the milk contains swarms of bacteria at the very beginning. As harmless and harmful bacteria alike multiply in milk, it is important to keep them from getting into it. There are several important points to remember in milking:

(1) No person who has had typhoid fever within twelve months should be allowed to handle the milk, unless a physician has made a test and pronounced the patient free from dangerous germs. A typhoid carrier infects the milk with his hands or by coughing over the milk bucket.

Every milker should wash his hands with soap and water before milking.

(2) Dust carries many bacteria into milk. To prevent this the cow's udder should be washed before milking. A milk bucket with a small opening, as shown on the right of Figure 88, should be used. If the milk is intended for the baby, it is well to milk through a scalded cheesecloth stretched over the bucket. The cloth should be scalded before each using. It is, of course, needless to add that flies should be kept from wiping their feet on any of the milk vessels.

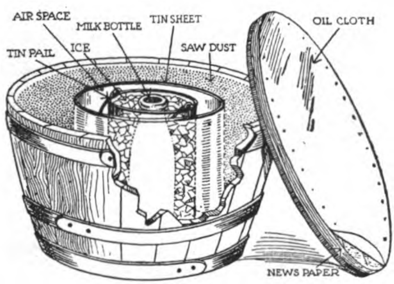


Figure 89. — A home-made ice box for keeping milk cold and sweet.

Care of the Milk. Germs will not grow and multiply rapidly in the cold. The warm milk from the cow should be cooled at once after straining and should be kept on ice. In case ample cooling facilities are not at hand, at least milk intended for the baby should be kept cold until it is to be used, when it can be quickly warmed. Figure 89 shows a simple, inexpensive form of home-made ice box. The milk room should be screened and free from flies.

Dairy Inspection. When a person has his own cattle, it is a comparatively simple matter to have everything connected with the care of the milk clean and sanitary. Those who get their milk from a dairy, however, find it hard to get absolutely clean milk. It is well to patronize a dairy that you know is sanitary, and it is well to pay the dairy an occasional visit. Every one should try to secure proper laws for the regulation of the milk supply and to see to it that these laws are enforced.

SUMMARY

Remember particularly the following points:

1. Care should be taken in the selection of food. In planning a meal we should select a variety of foods so that all of the foodstuffs are represented.
2. Canned goods should be examined carefully before using, for they occasionally contain poisonous germs.
3. Above all, we should select food free from disease germs.
4. Cooking kills germs and makes many foods, particularly most vegetable foods, more digestible and more palatable.
5. Milk is so important a food and so often contains dangerous germs that every care should be taken to secure pure milk.
6. Milk may be infected with dangerous germs from dust, from flies, and from the milker's hands and throat.
7. Milk should be drawn into a bucket covered with a scalded cheesecloth, and should be strained and put on ice at once.

QUESTIONS

1. What is meant by a mixed diet? 2. Select for a dinner five foods that will together constitute a mixed diet. 3. Why is it better to eat a sandwich and fruit for a school lunch than candy and pie? 4. Discuss the danger from canned foods. 5. What are the most harmful things that get into food? 6. State three advantages of cooking food. 7. What foods should be cooked long and at a high heat? 8. Why is milk an important food? 9. Why may milk be also a dangerous food? 10. What diseases are known to be scattered by infected milk? 11. Why should milch cows be tested for disease? 12. Discuss fully how we can prevent bacteria from getting into milk. 13. Why should milk be kept cold? 14. How could you make a cheap ice box sufficiently large for keeping several bottles of milk? 15. What does Figure 86 illustrate? Figure 87?

CHAPTER XXV. THE MEANING OF DIGESTION

The proper selection of food in the market and its preparation in the kitchen are important; but the food is even then not ready for the blood. In the mouth, stomach, and intestines the food is changed very much. It is ground up, mixed with juices, and becomes liquid before the blood receives it to carry it to all parts of the body. The following experiments should be performed to illustrate the changes the food undergoes in the body:

PRELIMINARY EXPERIMENTS. (1) Take two tumblers half full of water. In one place a lump of salt (table salt); into the other drop the same quantity of salt that has first been powdered by grinding in a mortar or with a hammer on a smooth board. In which tumbler does the salt dissolve faster, and why? To another tumbler add a little starch. Does this dissolve like the salt? The salt is said to be *soluble;* the starch *insoluble.*

(2) Procure three tumblers with water, a quantity of hydrochloric (muriatic) acid, and three small pieces of limestone or marble about the size of a pea. Drop one piece of limestone into tumbler No. 1. To both the other tumblers add a few drops of acid. To tumbler No. 2 add a piece of marble in a lump; pound the other piece of marble to pieces and add them to tumbler No. 3. Tumbler No. 1 has water and a lump of marble only. Tumbler No. 2 has water and a lump of marble with acid. Tumbler No. 3 has water and fragments of marble with acid. Now observe the results. (Add more acid to Nos. 2 and 3, if bubbling should cease before the limestone is dissolved.)

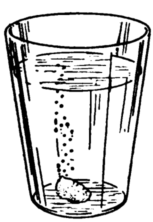


Figure 90. — Limestone dissolving in acid.

Putting together the results of the foregoing experiments, we reach the following conclusions.

1. That salt is soluble.
2. That starch is insoluble.
3. That limestone or marble is insoluble.

4. That acid will change limestone into a form that is soluble in water.

5. That salt in small particles is more readily dissolved than when in lumps.

6. That limestone is acted on more quickly when in small particles than when in a lump.

Digestion Defined. Digestion of food in the body consists of changing it and rendering it soluble, so that it may be taken up by the blood. There are two sides to the digestive process: first the mechanical and second the chemical. The mechanical changes consist mainly of breaking up the food into small particles, and its purpose is, as noted in the experiments above (conclusion 6), to make the chemical changes take place faster. In the chemical changes the food is changed into entirely new substances, just as starch is changed to glucose by acid and heat.

Mechanical Digestion. Mechanical digestion is performed mainly by the teeth, which in the process of chewing cut, tear, and grind the food into very small particles (Fig. 91 *A*). Chewing the food is extremely important. To eat a meal in a hurry, swallowing the food in large lumps (Fig. 91 *B*), is injurious and may cause various ailments. If food is improperly chewed, it is likely to decay or sour before it can be fully digested. Chewing is also

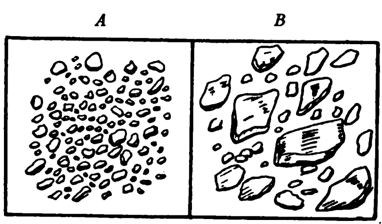


Figure 91. — Well chewed and poorly chewed food, magnified.

good for the teeth, for unless they are used sufficiently they will decay.

In the mouth the food is also moistened with saliva, which aids in swallowing. To show how hard it is to swallow dry food, crush a small cracker and try to swallow it quickly. Then try one that has been soaked in water.

The movements of the stomach and intestine are also important parts of mechanical digestion.

Chemical Digestion. When acid acts on limestone, it brings about a chemical change; the insoluble limestone is changed into a new substance which is soluble. Similarly, when starch is heated with an acid it is starch no longer, but is changed to glucose. In the body starch is not changed to sugar by strong acid or great heat, but by a certain substance in the saliva of the mouth and by another juice found in the intestines. The action of saliva on starch is almost the same as that of acid and heat; saliva changes starch to sugar. Such a change is called a chemical change, and the process in the body is called chemical digestion.

The active agents of the digestive juices that bring about chemical digestion are called *enzymes*. There are a number of enzymes in the mouth, stomach, and intestine, and each enzyme acts on a single kind of foodstuff. For example, amylase is the enzyme that changes starch to sugar. The most important enzymes are given in the table at the end of this chapter. The chemical digestion of starch by saliva can be studied in the following experiments:

EXPERIMENTS TO PROVE THAT STARCH IS CHANGED TO SUGAR BY SALIVA. (1) Taste a piece of clean wood; chew it a little. Has it a sweet taste? Take a piece of cracker soaked in water and note whether it has a sweet taste the moment it is taken into the mouth; or does it at first taste like wood? Chew it and note the result. Why does not the wood taste sweet just as the cracker does after it is chewed awhile? (2) Let one of the pupils chew half a cracker for a few minutes. Have a small portion of the now nearly liquid contents of his mouth placed in a test-tube. Add Fehling's solution and boil as in the experiment given elsewhere. The red color proves that a considerable quantity of sugar is present.

Starch must be changed to sugar before the blood can take it up. Proteins are changed to soluble substances, which we may call animal acids. Fats are also digested. The first step in the digestion of fats is similar to the making of soap. In making soap, fat and an alkali are put into a pot and boiled. In the human intestines there is an enzyme that digests fat by changing it, with the aid of an alkali from the glands, to a kind of soap. *Glycerin* is formed out of the fat in addition to the soap.

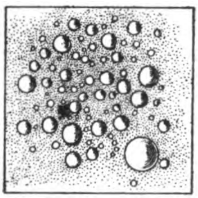


Figure 92.— Oil globules in milk.

SUMMARY

Digestion of food in the body consists of changing insoluble into soluble foodstuffs: first, by the thorough chewing of the food, or mechanical digestion and next by chemical digestion due to the various juices called digestive juices: by means of which starch is changed to sugar, proteins to animal acids, and fats to soap and glycerin.

The following table shows the juices and enzymes that act upon the different kinds of food, and the digestive organ in which the action takes place in the process of chemical digestion:

DIGESTIVE ORGANS	JUICE	ENZYME	DIGESTS
Mouth	Saliva	Amylase	Starch
Stomach	Gastric Juice	Pepsin (Rennin)	Protein (Curdles Milk)
Small Intestine	Pancreatic Juice	Trypsin Amylase Lipase	Protein Starch Fats
	Intestinal Juice	(Invertin)	(Cane Sugar)

QUESTIONS

1. Define soluble; insoluble. 2. Mention several soluble and several insoluble substances. 3. What does Figure 90 illustrate? 4. Describe an experiment illustrating digestion. 5. Define mechanical digestion. 6. Describe an experiment that shows the value of chewing our food. 7. What is meant by a chemical change? Illustrate. 8. In the experiment with saliva, how can you prove that the starch has been changed to sugar? 9. Where are enzymes found, and what work do they do? 10. Name the digestive juices. 11. How are fats digested? 12. Mention the foodstuffs that have to be digested, and tell into what each is changed in the processes of digestion.

CHAPTER XXVI. WHERE DIGESTION BEGINS

The Mouth

Where Digestion begins. The organs of digestion are the various parts of the food-tube or alimentary canal and the several organs called *glands* that communicate with the alimentary canal. The food-tube begins at the mouth. The other organs can be seen in Figure 93. Draw Figure 93 on paper or on the blackboard, and after comparing it with Figure 73 name the digestive organs on your drawing.

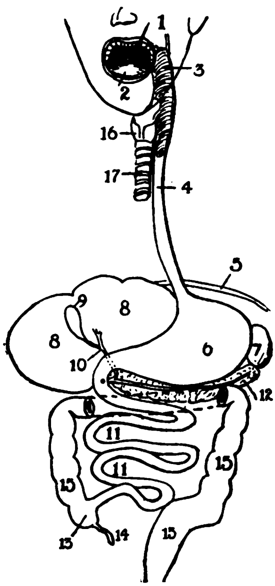


Figure 93. — Outline of the principal digestive organs. (Compare with Figs. 71 and 73.)

The Mouth. Name the organs found in the mouth. What bounds the mouth on the sides? in front? The roof of the mouth

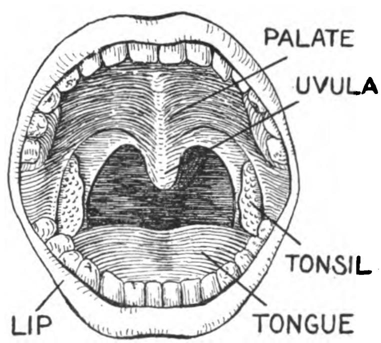


Figure 94. — The mouth cavity.

is called the *palate* (Fig. 94); the hard palate, nearer the front, can be touched by the tongue pressed upward; the soft palate passes backward and ends in a flap called the *uvula*. The mouth communicates behind with the throat or *pharynx* and is partly separated from this by the soft palate. Stand before a mirror facing the light, and study in your mouth the organs shown in Figure 94.

Chemical Digestion in the Mouth. Review the chemical action of saliva on starch. The saliva is produced by three pairs of *salivary glands*, placed as shown in Figure 95. These glands empty their juice, the saliva, through openings on the inside of the cheek (*DP*) and under the tongue (*DS*). A further use of saliva is to moisten the food so that we may swallow it. Saliva also keeps the inside of the mouth continually moist.

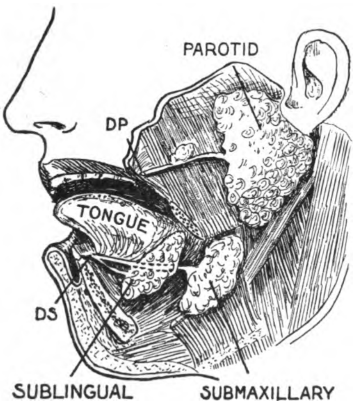


Figure 95. — The salivary glands of the left side.

The *tongue* is a muscular organ attached behind to the tongue bone (Fig. 121). Chew a mouthful of food and note exactly how the tongue handles it. Place a little salt on the tip of your tongue; can you taste it without drawing back the tongue? What letters of the alphabet are made in speech mainly by the tongue? By the lips? By the teeth? State three functions of the tongue suggested by these questions.

The Teeth

Structure of a Tooth. A tooth is composed of a crown, a neck, and one or more roots. The *crown* is the only part of the tooth that is visible. It is covered with *enamel*, the hardest material in the body. This enamel protects the rest of the tooth. The *roots* stand in sockets in the jaw-bones (Figs. 96 and 97) and are covered with *cement*, a bony substance not so hard as enamel. Under enamel and cement is the bonelike *dentine*, which forms the bulk of the tooth. A cavity, the *pulp-cavity*, is the hollow in the middle of the tooth running up into the dentine. The pulp-cavity is filled with connective tissue, nerves, and blood vessels. The relation of these parts can be better understood by reference to Figure 96, or still better by studying a section of a real tooth as instructed in the next paragraph.

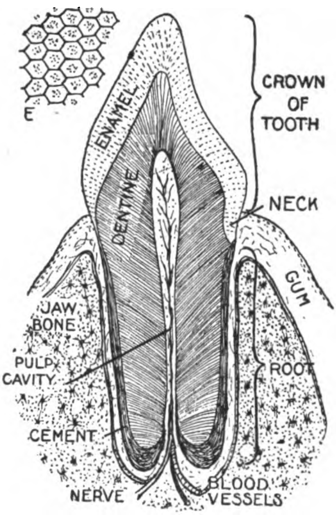


Figure 96.—Section of a tooth, showing its parts. *E*, surface view of the enamel, highly magnified.

Observation Work on a Tooth. Secure a molar tooth of a horse or a cow (as these are large) or ask a dentist for a human tooth. A tooth not too old and dry is to be preferred. Have a blacksmith saw this in two with a hack saw. Then for a few minutes vigorously rub the surface of each half on a whetstone, using plenty of water. The two halves should now clearly show the parts of the tooth.

Different Forms of Teeth and their Functions. The adult human being has thirty-two teeth. Figure 97 gives the outlines of the teeth of one half of the upper and one half of the lower jaw. In each half-jaw there are two incisors, one canine, two pre-molars (bicuspids), and three molars. The incisors are flat and sharp; the canines are cone-shaped. These teeth are for biting and tearing the food. The bicuspids and the molars have wide surfaces for crushing and grinding the food and mixing it thoroughly with the saliva.

The Two Sets of Teeth, Temporary and Permanent. Every person has in his lifetime two sets of teeth. Why is this? It is because the jaws in childhood are too small to hold the large teeth we need in later life; the first teeth must make room for the new teeth that push up under them. In early life, we have a set of twenty small *temporary teeth* (Fig. 98), five to each half-jaw. The first teeth of this set appear at about the age of six months, and the set is completed at about the age of two years.

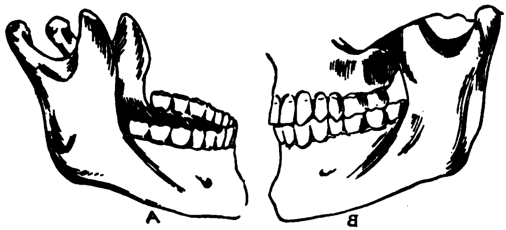


Figure 97. — The permanent teeth. *A*, the teeth in the lower jaw; *B*, upper and lower teeth of one side.

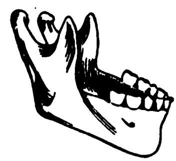


Figure 98.— Child's lower. jaw with temporary teeth. (Compare with Fig. 97.)

The First Permanent Molars. The earliest permanent teeth to appear are the *first molars*, which come behind the temporary molars about the sixth year. The permanent set is complete at the twelfth or thirteenth year of age, with the exception of the third molars, the so-called wisdom teeth, which appear about the eighteenth year or later.

Observation Work and Experiments on the Teeth. With a mirror study the shape of each of your teeth and from their shape judge what is the function of each kind: whether cutting, tearing, or grinding. Imagine yourself biting off a piece of bread and note how the incisors of the lower jaw move over those of the upper. Observe how the jaw moves during this process. Now, note the cusps or points on the back teeth. Observe how the cusps of the upper and the lower back teeth fit into each other when the jaws are tightly closed. Move the jaw as if chewing. How does the lower jaw move in the grinding, as compared with the biting, movement? You can now understand how the food is crushed and ground to pieces as the lower teeth slide across the upper. You can also understand how important it is that the teeth should be *regular*, so that the upper and the lower shall fit together properly.

Count your teeth. How many have you? Name each tooth. Look at the teeth of a boy or girl six or seven years old. If there are three double teeth on one side of the jaw, the back one is the *first permanent molar*.

If possible, examine the incisors of a gnawing animal, as a rabbit, a squirrel or a mouse; the teeth of a dog or a cat; the molars of a horse or a cow. What is the relation of the shape of the teeth to flesh-eating or plant-eating habits of animals? Judging from his teeth, what kinds of food is it natural for man to eat?

Importance of the First Permanent Molars. These teeth are so important that they have been called the keystone of the arch of the teeth. They should never be pulled or allowed to decay, for if they are missing, the jaws and other teeth cannot grow properly and the power of chewing properly will be lost. On account of the early appearance of the first permanent molars, parents frequently mistake these teeth for temporary teeth and allow them to decay, thinking that other teeth will come in their places. It is important, therefore, to learn to recognize these teeth when they appear.

Importance of the First or Temporary Teeth. The first, or temporary teeth, perform the same functions for the child that the permanent teeth perform for the adult, and it is important to care for them and to keep them sound until they are ready to be shed. If these little teeth decay and ache, the child suffers from toothache just as a grown person suffers. Besides, if the temporary teeth are extracted before they are ready to be shed, the jaws contract or do not grow large enough to hold the next set of teeth, which will then come in crooked.

Causes of Irregular Teeth. The main cause of irregular teeth is the premature loss of the temporary teeth. Certain habits of babyhood or childhood, such as sucking the thumb, biting the lips, or breathing through the mouth, may cause the upper teeth to protrude. If the teeth are not used enough in chewing good solid food, the teeth and jaws do not develop well, for they need exercise just as the arms do. If the teeth are not regular, they should be straightened. It is easier to do this when a person is young than later on in life.

There are three reasons why a crooked set of teeth should be straightened: (1) They can do their work better, and when the teeth chew the food well, the whole body is more healthy. (2) The teeth do not decay so easily when they are regular. (3) Straight teeth improve one's personal appearance.

The Unclean Mouth. Decay of the teeth is the commonest disease in the world, and it is due to uncleanliness. The reasons for this statement are as follows: A tooth consists largely of limestone. From the experiment described on another page you learned that limestone is dissolved by acids. Strong acids decay the teeth rapidly, and weak acids do so in time. Now, there are many bacteria in the mouth that live in food substances left there after eating. The bacteria form acids from the food. It is now thought that *tartar*, a dark, hard substance that collects on neglected teeth, is also caused by a germ. Decay often occurs under this tartar. When decay once begins, it spreads rapidly. Every decaying spot in a tooth should be repaired without delay. Indeed, it is a good plan to visit a dentist once or twice a year to have the teeth examined for any decay that may have started or for the removal of any tartar that may have formed on them.

Other Diseases of the Teeth. Among other germ diseases of the unclean mouth may be mentioned inflamed gums, abscesses of the teeth, blood poisoning, and *pyorrhea* or Riggs' disease. The last-mentioned is caused by pus-forming germs that lodge under the gums and around the roots under tartar or other hard deposits. The membranes of the roots and their bony sockets become infected, the teeth become loose, and pus flows from under the gums. This often causes foul odors to come from the mouth. Thorough cleanliness is a preventive of Rigg's disease as well as of other diseases of the mouth and teeth.

Effect on the Stomach. A further argument for mouth hygiene is the effect of germs on the stomach. Many of the germs in the mouth are swallowed and enter and infect the stomach. Furthermore, if the teeth are defective, a person will not chew his food well; the food is swallowed in large lumps and the stomach is burdened with additional work. An unhealthy mouth is sure, sooner or later, to result in an unhealthy stomach. Poorly chewed and poorly digested food are both likely to decay in the stomach and intestines. When the products of such decay are absorbed by the blood, they cause general harm to the body and indirectly affect the teeth, causing early decay.

Care of the Mouth and Teeth. It is, of course, important that the enamel should be preserved from mechanical injury. Such injury is likely to result from biting a hard object, such as a nut, or from picking the teeth with a hard instrument, such as a knife or a pin. The enamel is not one solid piece, but it consists of thousands of six-sided prism-shaped pieces set close together, like the bricks of a pavement. The prisms are shown in surface view at *E*, Figure 96. If some of these prisms are broken, others will break soon after. Extremely hot or cold food or drink should be avoided, because rapid changes of temperature are likely to crack the enamel.

The secret of mouth hygiene, however, is *cleanliness*, — the avoidance of germs in the mouth. The best way to avoid germs is to remove their food, the remnants of the meals that are left in the mouth.

Brushing the Teeth. The things most needed to clean the teeth are a tooth-brush of suitable size and shape, waxed dental floss or silk floss, a tooth powder, and pure soap and water. The brush should be moderately stiff. If the gums bleed from brushing, it shows that the mouth has been neglected. As you persist in the regular use of the brush, the gums will become hard, firm, and healthy. The brushing of the gums promotes circulation and prevents them from becoming soft or spongy.

In brushing the teeth the brush should be moved up and down on the gums and teeth, on the inside as well as on the outside. This allows the bristles to pass between the teeth to remove food particles lodged there. After this, the teeth should be brushed crosswise. After the teeth have been brushed, the top of the tongue should be brushed as far back as possible. The teeth and tongue should be well brushed before breakfast and after each meal.

Precipitated chalk is a good tooth powder for occasional use and is useful as a polisher. Waxed silk floss is better for cleaning between the teeth than toothpicks and should be used after each meal.

SUMMARY

In the mouth starch is partly digested by the amylase of the saliva. The mechanical work of tearing and grinding the food is still more important, for this prepares the food for all the chemical changes in the process of digestion. The teeth are so important as organs of mechanical digestion that no pains should be spared to preserve them. The teeth can be preserved only by strict cleanliness, and especially by the removal of remnants of food left in the mouth after meals; for decay is brought about by the agency of acid forming bacteria living on food remaining in the mouth. All defects of the teeth, such as decay and irregularities, should be promptly corrected by the dentist.

QUESTIONS

1. Name and locate the digestive organs. 2. Mention the organs that can be seen by looking into the open mouth. 3. Describe the process of digestion in the mouth. 4. What are the uses of the tongue? 5. Locate the salivary glands and tell where the duct of each opens in the mouth. 6. Describe the structure of a tooth from an outline figure placed on the blackboard. 7. Point out the different kinds of teeth in the mouth. 8. Why are the first permanent molars important? 9. Give reasons why the temporary teeth should be preserved. 10. Name causes of irregular teeth. 11. What causes the decay of teeth? 12. State the harmful effects of the unclean mouth. 13. Describe fully how to clean the teeth.

CHAPTER XXVII. OTHER DIGESTIVE ORGANS

THE GULLET, STOMACH, AND INTESTINES

As the food is swallowed, it passes through the pharynx or throat (Fig. 121) into the gullet or esophagus. This organ is nearly straight and leads directly to the stomach. The stomach has a greater diameter than the other parts of the alimentary canal and its walls are thicker. Joining the stomach at its lower end is the small intestine. This is by far the longest part of the canal, measuring from twenty to thirty feet in length. This length necessitates its being coiled up in the abdominal cavity. The small intestine joins the large intestine in such a way as to leave a blind sac (13, Fig. 93). To this is attached the *vermiform appendix* (14), a useless organ. When this becomes diseased, the patient is said to have *appendicitis.*

Thus from the throat downwards the alimentary canal is a hollow tube having muscular walls and lined with smooth epithelial tissue called *mucous membrane.* This is only one cell thick in the stomach and intestine (*A*, Figs. 108 and 109) but it is much thicker in the mouth and gullet. It is red from the presence of much blood so close to the surface.

The Gullet. The gullet is the passage way by which the food passes from the throat to the stomach. Liquid food passes down the gullet very quickly, but solid food is forced down by a movement of the muscles of which the wall of the gullet is largely composed. These muscles are in two layers. In the outer, thinner layer the muscles run lengthwise; in the inner, thicker layer they run in rings around the canal as shown in the upper portion of Figure 102. These ring muscles successively contract behind each lump of food, so that a wavelike motion passes along the canal, pushing the food before it. This can be seen by observing the throat of a horse drinking water. The waves running along the neck of the horse indicate the passage of each swallow of water down the gullet (Fig. 99). This wavelike motion is called *peristalsis*, and it is made by the intestines and part of the stomach as well as by the gullet. The action of a ring muscle may be further illustrated by puckering up the mouth as in the act of whistling,

Figure 99. — Ring muscles carry swallows of water up the horse's throat.

for there is just such a muscle around the mouth. Such ring muscles, controlling openings, are called *sphincter muscles*.

The gullet is not very likely to become injured or diseased. The commonest disease of the gullet is scarring from concentrated lye swallowed by mistake. The scars contract and make the gullet so narrow that not even water can trickle through.

The Stomach. The stomach is a large, baglike organ situated under the diaphragm (Fig. 71). It possesses a layer of oblique muscle fibers as well as ring and longitudinal muscle layers. In the walls of the stomach are found organs not present in the gullet. The mucous membrane of the stomach dips down into the wall, forming

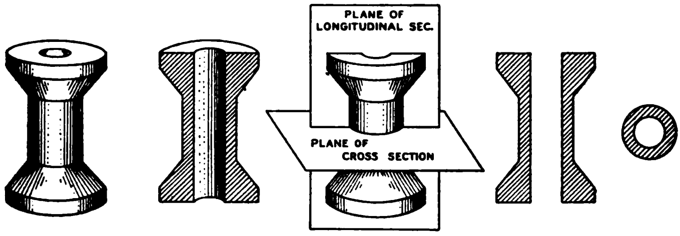


Figure 100. — *A*, a spool; *B*, half of a spool cut longitudinally; *C*, manner of cutting spool to get *D* and *E*; *D*, a longitudinal section; *E*, a cross section.

tiny sacs or pockets. These are the *gastric glands*. They can be seen in section in Figure 102.[1] The gastric glands secrete *gastric juice*. Each gland is very tiny, but there are so many that when all act together a large quantity of gastric juice is secreted.

When the muscles in the walls of the stomach contract, the food is thoroughly mixed with gastric juice. But only the lower, smaller half of the stomach engages in this movement, the food remaining more or less quiet in the large end of the stomach for some time after it is swallowed.

The Pylorus. At the point where the stomach passes into the intestines, there is a ring muscle which is unusually thick. When this contracts it closes the opening so as to keep the food in the stomach, just as a lady's handbag is closed by pulling the strings. When the muscle relaxes the food may pass from the stomach to the intestines. This muscle, then, acts like a valve. It is called the *pylorus* (Fig. 102), or gateway to the stomach.

[1] In describing the structure of organs the terms "longitudinal section" and "cross section" are frequently used. With the aid of Figure 100 these terms should be explained and applied to illustrations representing such sections.

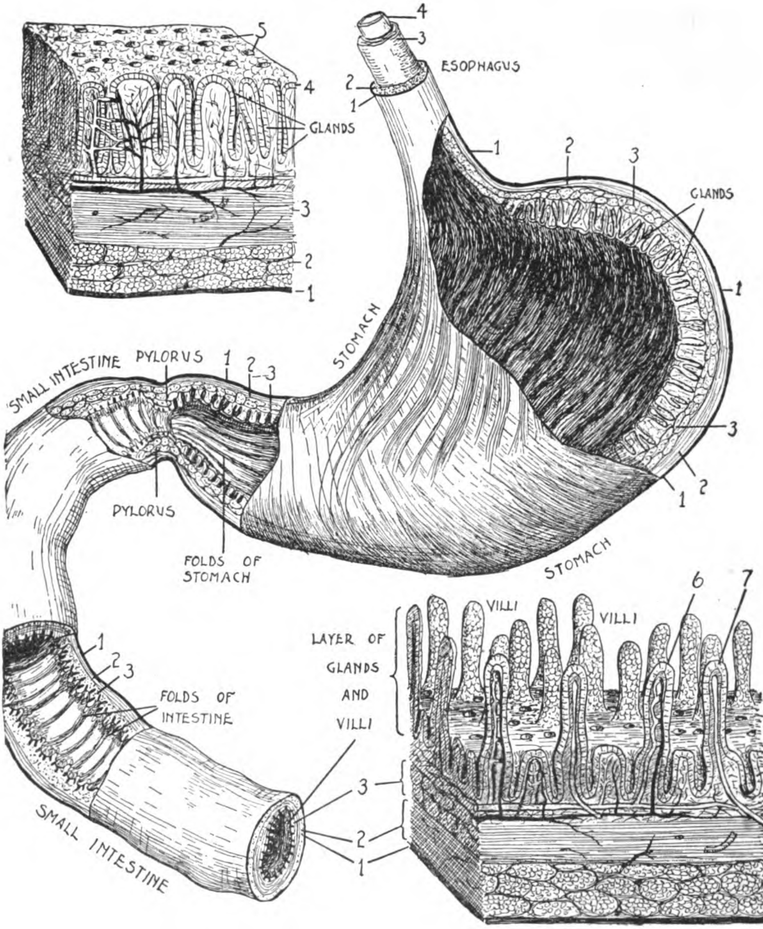


Figure 101. — A portion of the wall of the stomach, much enlarged; 1, peritoneum; 2 and 3, muscle layers; 4, lining of stomach; 5, mouths of glands.

Figure 102. — Gullet, stomach, and small intestine, partly laid open. Numbers same as in Figure 101.

Figure 103. — A portion of the wall of the small intestine, more enlarged than Figure 101; 6, villi containing blood capillaries; 7, villi containing lymph capillaries; other numbers as in Figure 101.

The Small Intestine. The small intestine has also a wall of muscle, both circular and longitudinal. The motion of the muscles results in moving the food forward along the intestine and in thoroughly mixing the food with the various juices that are poured into the canal. The mucous membrane lining the small intestine is more uneven than that of the stomach. Pocketlike glands, similar to the gastric glands of the stomach, extend back into the wall of the intestines and open by tiny mouths all over the inner lining shown in Figure 103. These are called the *intestinal glands*, and they secrete *intestinal juice.* But in addition to these glands there are fingerlike outpushings of the mucous membrane called *villi* (singular *villus*). That is, whereas the glands lead down from the surface into the wall, the villi extend up into the hollow of the intestine. In this connection carefully study Figures 102 and 103. The large intestine has no villi.

The Liver and the Pancreas. We have thus far learned of three kinds of *digestive glands;* that is, glands that make

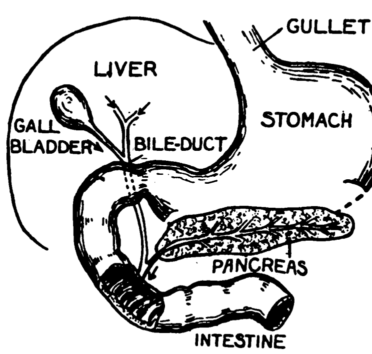


Figure 104. — Some of the important digestive organs of the abdomen.

or secrete digestive juices. These are the salivary glands, that pour saliva into the mouth; the gastric glands in the walls of the stomach; and the intestinal glands in the walls of the small intestine. Besides these there are two others, the largest and most important of all: the *liver* and the *pancreas*. The liver is a very large gland occupying the space just under the diaphragm, especially on the right side. The liver secretes *bile*. It does this all the time, and when the bile is not being used it is stored in a bag, called the *gall bladder*. The pancreas is a long gland lying behind and below the stomach (Fig. 73). It secretes the *pancreatic juice*. Bile and pancreatic juice are carried to the intestines by ducts which join and empty the juices into the intestines together (Fig. 104).

Digestion in the Stomach. In the large part of the stomach the digestion of starch by the action of amylase continues for some time. In the lower part of the stomach the gastric juice is mixed with portions of the food. Here proteins are acted upon and changed by an enzyme called *pepsin*.

Digestion in the Small Intestine. In the small intestine all the food (except glucose) undergoes chemical change. The intestinal juice contains enzymes that digest cane sugar. The pancreatic juice has enzymes capable of digesting proteins, starch, and fats. It is the most powerful digestive juice in the body. The bile has no enzyme, but it is useful in aiding the pancreatic juice to do its work and in keeping the mucous membrane of the intestines in good condition. The liver and the pancreas have other functions besides that of producing digestive juices.

The Hygiene of Cheerfulness. Saliva and gastric juice are found to secrete best when the food is attractive in appearance and pleasing to the taste. They have been called the appetite juices. They secrete better, too, and the intestine also carries on its peristaltic movement better when a person is in a cheerful mood. Anger, fear, sorrow, worry — all interfere with the secretion of the appetite juices and with the proper mixing of the foods with them.

Skilful preparation of food and a clean and attractive appearance of the table and the dining room add to the value of the food. Meal time, too, should be the pleasantest time of the day.

Summary and review of the chemical action of the digestive juices to show what juices digest the various foodstuffs and where:

Juice	Produced in	Emptied into	Digests
Saliva	Salivary glands	Mouth	Starch [2]
Gastric [1]	Gastric glands	Stomach	Proteins [2]
Intestinal	Intestinal glands	Small intestine	Cane sugar
Pancreatic	Pancreas	Small intestine	Starch [2] Proteins [2] Fats [2]
Bile	Liver	Small intestine	Aids other juices

SUMMARY

The alimentary canal is a long tube which begins at the mouth and includes the throat, the gullet, the stomach, and the small and the large intestines. The tube is lined with mucous membrane. The wall of the canal is made mainly of muscles which, by contracting and expanding, mix the food with the juices and move it along. In the walls of the stomach and the small intestine are many small glands; other glands (salivary glands, pancreas, and liver) are outside the canal but pour their juices into it through ducts.

The small intestine is the most important organ of chemical digestion. It is the only organ where sugar and fats are digested, and in it the digestion of the proteins and starch is completed.

[1] Gastric juice also contains an acid (hydrochloric acid) which helps to destroy germs that get into the stomach. The acid also aids in digestion. Gastric juice will also curdle milk.

[2] See Chapter XXVII for digestion of starch, proteins, and fats.

QUESTIONS

1. Mention the parts of the alimentary canal numbered in Figure 93. 2. With a spool before you, draw a cross section and a longitudinal section of the spool. 3. Do the same for a top. 4. Sketch cross sections of the gullet, the stomach, and the small intestine. 5. What is the use of the muscle layers of the alimentary canal? 6. How is this use illustrated in Figure 99? 7. Describe the pylorus. 8. Draw a longitudinal section through the pylorus (Fig. 102). 9. Where is the mucous membrane found? 10. Locate the gastric glands. 11. Compare these glands with the intestinal glands. 12. Where are the villi found? 13. From what part of Figure 102 is Figure 101 supposed to be taken? 14. In what organs is starch acted on? Proteins? 15. What is the only juice that can digest fats? 16. What foods are digested in the intestines? 17. Where is the chemical digestion of proteins begun? Of starch? Of fats? Of cane sugar? 18. Why does pleasant conversation at the table and cheerful company add to the value of food? 19. How does tasteful preparation of food conduce to health?

CHAPTER XXVIII. THE DIGESTIVE GLANDS

Definition of a Gland. You know by this time at least what a gland does; that is, that it produces or secretes, that is, takes up from the blood, a fluid or a juice. You could make a list of at least four digestive juices and tell by what glands they are secreted.

The mouth is always moist because the salivary glands secrete saliva and pour it into the mouth. There are many different kinds of glands in the body besides those already mentioned, as for example the tear glands and the sweat glands.

How the Gland Cells Are Arranged. Let us point out the kinds of cells that glands are composed of and how

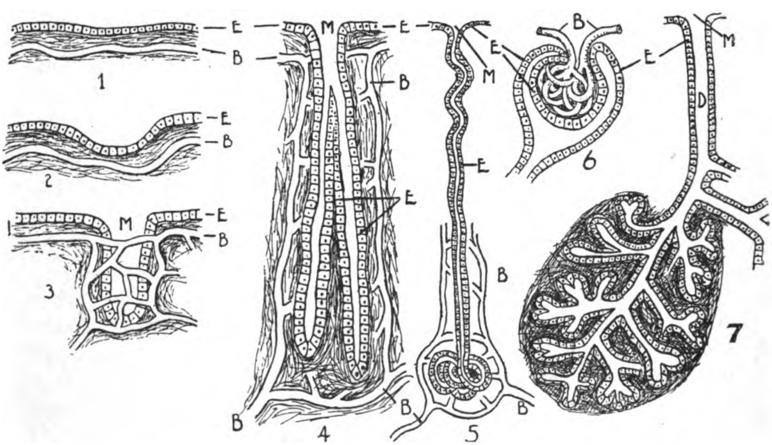


Figure 105. — Diagrams of various types of glands. *E*, epithelial layer consisting of gland cells; *H*, blood capillaries; *M*, mouth of gland; *D*, duct. 1, gland with flat epithelial layer; 2 and 3, pocket-shaped glands; 4 and 5, tubular glands, the one at 5 having tube so long as to necessitate its being coiled up at the lower end; 6, gland with blood vessels coiled up inside of epithelial layer; 7, compound gland with many pockets and ducts.

these cells are arranged. *Gland cells are epithelial* (*E*, Fig. 105); that is, they are arranged side by side so as to make a layer, as shown in the diagrams in the figure. This layer has one surface lying against the connective tissue, in which there is a rich supply of blood vessels. Where these come close to the gland cells they are thin-walled, so that the substances may readily be taken out of the blood by the cells. These substances are changed by the cells into juices which ooze through the cells and are given off on the free side of the epithelial layer.

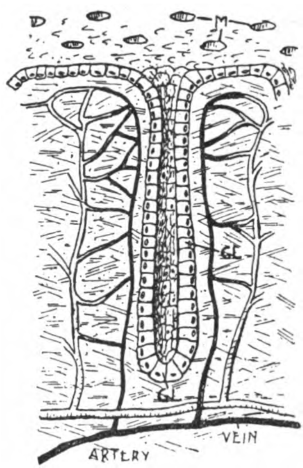


Figure 106. — A gastric gland from Figure 101, highly magnified. *GL*, gland cells; *M*, mouths of other glands.

Diagram 1 of Figure 105 represents the glandular layer as flat. A gland of this kind, if extended, takes up a great deal of space; therefore most glands have the secreting surface pushed down into pockets and tubes, as figured in longitudinal sections in diagrams 3–7, Figure 105. Blood vessels surround these glands and come close to the gland cells; the hollow of the gland serves to catch the secreted fluid and to give it off at the opening, the mouth of the gland (*M*).

The relation of blood vessels and gland cells is again shown in Figure 106. Just such glands are found in the walls of the stomach and the intestines. They may be simple, as shown in Figure 106, or compound, that is, with several branches, as in diagram 4, Figure 105. Their exact position is seen in Figure 102, where the walls of the stomach and the intestines are represented as cut away, exposing sections of the walls. These glands are very small, — much smaller than shown in Figure 102, which has the stomach about one fourth natural size, but shows the glands enlarged five or more times. Figure 101 represents a block of the stomach wall more enlarged;

it shows how numerous are the gastric glands in the stomach.

The intestinal glands are similar, usually simple, like the gastric gland shown in Figure 106. Study them also in Figure 103. Among the glands are projections, the villi, which project out from the walls while the glands extend down into them. The duty of the villi we shall study in the next chapter.

Other Glands. The glands just described occupy all the space available in the stomach and the intestines, but

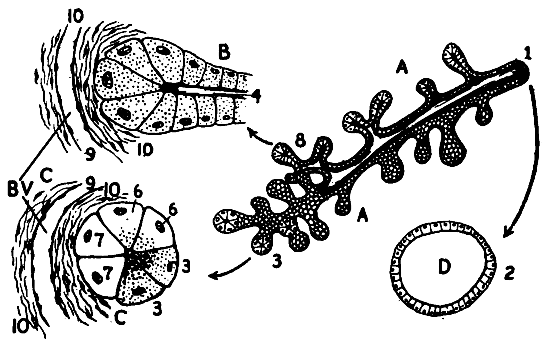


Figure 107. — Details of tiny portion of pancreas. *A*, a number of pockets that empty their juice into duct (partly cut open); 8, a pocket in longitudinal section, more highly magnified at *B*; 3, a pocket in cross section, more highly magnified at *C*; 1, large duct, more highly magnified at *D*; 4, small duct; *BV*, blood vessel; 5, appearance of gland cells before a meal; 7, after a meal.

they are not sufficient to supply the alimentary canal with all the digestive juices needed. There are, therefore, other glands of large size outside the canal, but communicating with it by ducts or tubes, to carry the juice from the gland to the proper organ. As already noted, these glands are: six salivary glands, whose ducts lead to the mouth, and the liver and the pancreas, whose ducts lead to the small intestines. The salivary glands, the liver, and the pancreas are complex, not simple, glands, as are the gastric glands. But when carefully studied, each smallest part or unit of a large gland is found to be a little pocket of epithelial tissue. Each pocket corresponds exactly to a simple gland. A large gland, then, is a large collection of simple pockets, all of which empty their fluid into ducts or tubes that combine into one or more large ducts to carry off the fluid to the mouth or the intestines. As in all glands, the epithelial cells of each pocket get material from the blood wherewith to make their secretions. Study in this connection Figure 107.

SUMMARY

There are many different kinds of glands in the body, but they are all alike in having the cells that do the work arranged as an epithelial tissue which lies upon connective tissue very rich in blood. The cells secrete fluids; that is, they take materials out of the blood and make them over into various fluids. The digestive glands are of five kinds: (1) the gastric glands in the walls of the stomach; (2) the intestinal glands in the walls of the intestines, — these are very simple and numerous. Outside the alimentary canal, but communicating with it, are: (3) six salivary glands, (4) the pancreas, and (5) the liver.

QUESTIONS

1. What is a gland? 2. What is the principal kind of tissue in a gland? 3. What letter marks the layer of gland cells in Figure 105? 4. Where do the cells get the material from which to make their juices? 5. Which has more gland cells, 3 or 4 of Figure 105? 6. Describe a gastric gland. 7. Where are glands like this shown in Figure 101? 8. Locate them also in Figure 102. 9. Compare the glands of Figure 103 with the gastric glands. 10. What part of Figure 107 is like a gastric gland? 11. Why does the blood have to come near the working cells of a gland? 12. Where are the gland cells of Figure 106? Of Figure 107?

CHAPTER XXIX. HOW THE FOOD IS TAKEN UP BY THE BLOOD AND LYMPH: ABSORPTION

We have now considered digestion as the process of making insoluble food soluble. Only water and soluble substances can be taken up out of the digestive organs. Water, salt, and some sugars are taken up without change, but other foodstuffs, as we have learned, must be digested before they can be taken up. So long as the food remains within the alimentary canal, however, even after it has been digested, it does the body no good. Of what use can the food be to the cells of the hand, head, or other parts so long as it remains in the stomach or intestines? To be of use to any part it must be carried to that part. The food is carried to the distant parts of the body by the blood. In the stomach and the intestines the blood takes up the digested food. The process by which the food soaks through the wall of the alimentary canal is called *absorption*.

The Blood as a Carrier. The blood is the carrying agent of the body. The heart pumps the blood; and in order that the blood may flow quickly and surely to all parts of the body, it flows in definite tubes, called the blood vessels. *Arteries* are blood vessels that carry the blood away from the heart. These divide again and again and grow smaller and smaller the farther they pass from the heart, until they become so tiny that they cannot be seen without a microscope. The smallest vessels are called *capillaries*. They have walls so thin that substances can pass in and out through them. These capillaries combine again to form *veins*, which return the blood to the heart.

Thus the arteries carry blood to the capillaries in the walls of the stomach and intestines; the blood while passing through the capillaries absorbs food; and then, flowing into veins, the blood carries the food to the right side of the heart. It then flows through the lungs and back to the left side of the heart, from which, rich in the different kinds of food, it is pumped to all parts of the body.

The Lymph. You must also learn at this point that there is another fluid in the body, called the *lymph.* This absorbs some foods from the intestines and carries them into the blood. The lymph begins in the *lymph capillaries*, in the walls of the intestines.

Where the Food is Absorbed. The entire inner surface of the stomach and the small and large intestines is covered,

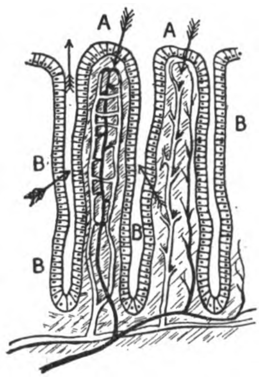


Figure 108. — Diagram of portion of wall of stomach, showing three gastric glands; *A*, absorbing cells; *B*, gland cells.

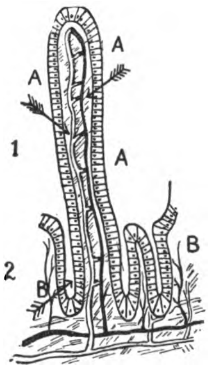


Figure 109. — Diagram of portion of wall of intestine, showing a villus (1) and three intestinal glands (2). The rest as in Figure 108.

as we have learned, with mucous membrane (1, Figs. 101 — 103). The whole mucous membrane is a soft, moist material, very much like a soft jelly. Just below this layer of mucous membrane lie an enormous number of tiny blood and lymph capillaries, so closely laid together that they almost touch one another. The dissolved food particles soak through the jellylike mucous membrane into the streams of blood and lymph. As these move along under the mucous membrane they continue to absorb from the mucous membrane the various foods, until all are absorbed from the inside of the stomach and intestines.

The insoluble part only is left behind to be cast off from the body.

In the stomach and the small and large intestines are various glands, gastric and intestinal glands (Figs. 101 and 103), which secrete digestive juices. These glands are lined with mucous membrane. The cells of the glands do not absorb food and pass it on to the blood, but on the contrary they take substances out of the blood and make juices of them, which they pass into the stomach and intestines. These glands are shown at *B*, Figures 108 and 109. The arrows indicate the direction in which substances pass out of the blood through the gland cells.

The Stomach and Intestines as Absorptive Organs. The stomach plays a very important part in the digestion of food, but a comparatively unimportant part in absorption. Most of the food is absorbed in the small intestine; some in the large intestine. The small intestine is the most important absorptive organ because it contains the most powerful digestive juices and because the digestion of all the foodstuffs is completed in it. Other reasons will be stated presently.

The Absorption of Water. Very little if any water is absorbed in the stomach; water is passed on at once to the small intestine, in which the greater part of it is absorbed. Most of what is left is absorbed in the large intestine. When the water is taken up too thoroughly in the large intestine, constipation results. To avoid this, water should be drunk just before going to bed at night and on getting up in the morning.

The Small Intestine as an Absorptive Organ. The lining of the small intestine is seen on examination with the naked eye to have a soft, velvety appearance. If examined with a hand lens, the velvety surface looks like the rough surface of a coarse bath towel. This is due to the presence of the tiny projections called *villi* which project up into the inside of the intestines. Figure 103 shows that the villi are scattered over the surface of the intestine among the intestinal glands.

The villi are covered with mucous membrane. Their function is to increase the extent of surface of the mucous membrane, for the greater the extent of the surface the greater will be the quantity of food absorbed. As there are several thousand villi to the square inch of surface, one can readily understand the advantage the small intestine has as an absorptive organ. Figure 109 represents a diagram of a portion of the wall of the small intestine. A villus is shown at 1. The cells at *A* are absorptive cells of the mucous membrane. A study of Figure 108, which shows the absorptive cells of the mucous membrane of the stomach at *A*, shows how little space the stomach has for absorption of food as compared with the small intestine. The surface of the small intestine is further increased by the great length of that organ.

Structure of the Villi. As noted above, the villi are covered over with mucous membrane through which the food is absorbed. To carry off the absorbed food, each villus has a fine meshwork of blood capillaries and one or more lymph capillaries (the latter are called *lacteals*). Three villi are shown in Figure 110, page 174. In II blood capillaries only are shown; III shows only a lacteal.

Course of the Absorbed Food. The blood capillaries and the lacteals divide the work of carrying off the absorbed food substances. The carbohydrates and proteins are carried off by the blood capillaries, the fats by the lacteals. *Lacteals* means "milk vessels," for after a meal they can be seen to be white as milk on account of the fat droplets they have absorbed.

By the time the blood reaches the heart, all of the absorbed food is mixed together, for the lymph carrying the fat is returned to the blood at a point above the heart. Figure 111, page 175, shows the course of the fats; the vein called the *portal vein* carries the carbohydrates and proteins to the liver, through which these foodstuffs must pass before being taken to the heart and pumped to all parts of the body.

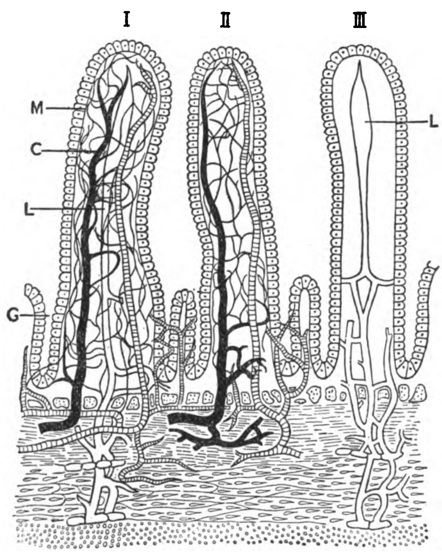


Figure 110.—Three villi of the small intestine: I, with blood capillaries (*C*) and lacteal (*L*); II, with blood capillaries only; III, with lacteal (*L*) only; *G*, intestinal gland.

How the Food is Absorbed: Diffusion. You have noticed that the food must pass through the jellylike mucous membrane to get into the blood; also through the walls of the blood vessels. We say it does this by diffusion, by which we mean that substances pass from the part of a solution where they are abundant to the part where they are less abundant. Thus food substances pass from the inside of the intestines into the blood and lymph, for there is less foodstuff in the blood and lymph, since the supply is continuously being carried away by the circulating liquids.

How gases diffuse is familiar to most people. Thus in a closed room in which there are no currents of air, gas in one part of the room will soon diffuse into all parts. How substances diffuse in liquids can be seen in the following experiment:

Experiment. Put some crystals of bluestone (copper sulphate) in the bottom of a tall glass jar, and pour water over them very carefully and slowly so that no mixing occurs. Set the jar aside in a perfectly quiet place, and from day to day look at the solution. The blue color gradually spreads to the top, showing that the bluestone diffuses into the water.

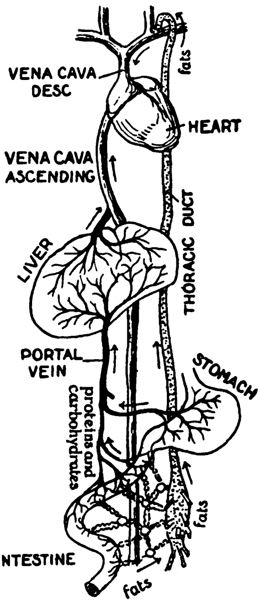


Figure 111.—Diagram to show the course of foodstuffs to the heart. Fats are carried in lymph vessels. The portal vein carries the other foodstuffs.

Diffusion through a Membrane. The part played by the membrane in diffusion is to keep out undesirable substances; it serves to allow only certain substances to pass through. Thus water, salts, animal acids, etc., will pass readily through the mucous membrane. Substances such as gelatin or the white of an egg do not diffuse to any extent. These must, therefore, be digested before they can pass through the mucous membrane and enter the blood. The following experiment illustrates how a membrane allows water, but not protein, to pass through.

Experiment. Take an egg, a glass tube or a straw about a foot long, a bottle to hold the egg, and a vessel to hold the bottle and the egg, as shown in the accompanying figure. With great care crack the shell at the large end of the egg and pick off the bits of shell with the finger nails, being careful not to injure the membrane under the shell. Or better, dissolve away the shell by immersing the egg in dilute hydrochloric acid; this can be done by placing the egg in a cloth bag and hanging the bag in the acid to the required depth. Now, punch a hole in the other end of the egg, and into this thrust a straw as far as the center of the yolk of the egg. With melted beeswax or paraffin or tallow seal the joint of the straw to the egg. Set up the apparatus, as in Figure 112, and add water, immersing half of the egg, and await results. If the membrane of the egg is not broken where it touches the water, the water will pass into the egg but the contents of the egg will not pass out. This causes the contents of the egg to rise in the tube. Watch the experiment and explain what you see.

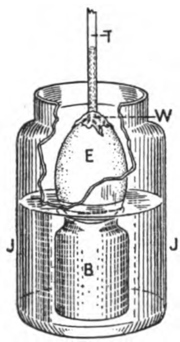


Figure 112.—Experiment in diffusion. *B*, bottle; *J*, jar; both containing water; *E*, egg; *T*, glass tube or straw sealed to egg with wax (*W*).

SUMMARY

After the food is digested it is worthless to the body unless absorbed by the blood and lymph and carried to the hungry cells of the body. The digested, or soluble food, is absorbed by diffusion through the thin mucous membrane lining the stomach and the intestines. The small intestine is the chief absorptive organ; its absorptive surface is very great and in it the digestion of all the foodstuffs is completed. The area of the inner surface of the small intestine is enormously increased by the great length of the canal and especially by the villi. The villi number thousands to the square inch, and each villus contains blood capillaries and lacteals, which carry the foods to the veins and through these to the pumping station, the heart.

QUESTIONS

1. Why must food get into the blood? 2. How does the food pass in? 3. Why must food be soluble in order to be absorbed by the blood? 4. What membranes must the food pass through to get into the blood (Figs. 108 and 109)? 5. Describe an experiment to

illustrate diffusion. 6. What is the principal use of the mucous membrane (*M*, Fig. 110)? 7. Describe a villus. 8. What membrane in Figure 110 corresponds to the membrane around the egg in Figure 112? 9. What organ in a villus takes up fats? Proteins and carbohydrates? 10. What foodstuffs pass through the liver before going to the heart? 11. What cells in Figure 110 are touched by the nearly liquid contents of the small intestine?

CHAPTER XXX. THE MAKING OF LIVING SUBSTANCE: ASSIMILATION

In the last few chapters we have discussed: (1) the kinds of food that are eaten; (2) how these foods are digested, or prepared for absorption; (3) how they are absorbed or taken into the blood to be pumped by the heart to all the cells of the body. We shall now consider how the food passes out of the blood to supply the cells.

Blood as the Carrier. It was noted in the last chapter that the blood vessels are everywhere closed and that food substances pass into the thin-walled capillaries of the villi by diffusion. Just so, after the blood has reached the hungry working cells in distant parts of the body, the food which the blood carries passes out through the capillary walls to the cells. The blood does not actually touch the cells, but stays in the blood vessels; it merely passes close enough to the cells so that, by diffusion, the food may pass to the cells, just as water passes into the egg through the membrane in the experiment described above. Figure 113 shows this relation of capillaries and cells of the body.

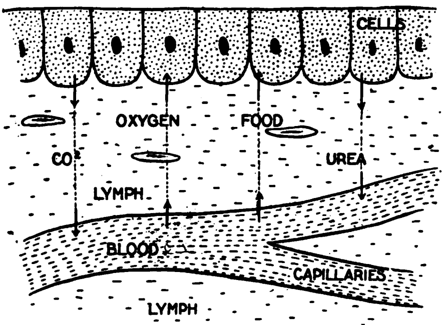


Figure 113. — Diagram to illustrate the relation of cells, lymph and blood. CO_2 = carbon dioxid.

The Lymph. Some cells of the body lie loosely together in such a way that there are spaces among them. This is especially true of connective tissue. Such spaces are filled with a thin, colorless fluid called *lymph*. It may be said that we — that is, our cells — live in a fluid just as fish live in water. You will note by studying the diagram (Fig. 113) that substances which pass from the blood to the cells must first pass through the lymph that fills all the spaces among the cells.

Assimilation. The question now is: What becomes of the food after it reaches the cell? This is the climax of the subject, — the food becomes in part living substance. Living substance makes dead matter over into living matter like itself. This is called *assimilation* (Latin *ad*, to, and *similis*, like). Living matter, found in all living cells, is called *protoplasm*. A cell, therefore, represents a definite mass of protoplasm (Fig. 76). In doing work a cell uses up some of its protoplasm, but it creates new protoplasm out of food brought to it; it repairs and adds to itself. No machine can perform such work as this of the living body. As explained elsewhere, however, proteins only can serve to form protoplasm. Indeed, it has been found that only certain kinds of protein can form it. Foods not used for assimilation are mostly used to furnish heat and energy for work.

Growth of Cells. It is easy to see from this how cells grow and multiply. As the body grows, more cells are

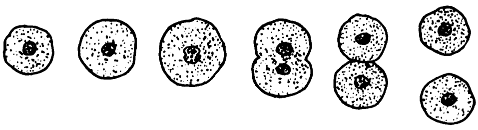


Figure 114. — Cell growth and division.

developed from those already there. The cell reaches its full growth and then divides in two (Fig. 114); then there are two cells to grow again and multiply as before. When the skin is injured it grows from around the edge of the wound, for the skin is formed only from skin cells already present. The material for growth is furnished by the blood under and in the skin. Assimilation, growth, and multiplication are processes that are performed only by protoplasm or living substance contained in the cells of animals and plants.

Wastes. In burning or oxidizing the tissues and food in the body, waste substances are produced by the cells. The chief waste substances [1] are carbon dioxid, water, and urea. Excessive quantities of these are harmful to the cells and must be carried away by the blood. So without end, from birth till death, protoplasm is built up out of food and torn down by oxidation (burned) that life may go on. It is truly life by death.

Food Storage. But some substances can be stored in the body, to be used in case of need when food cannot

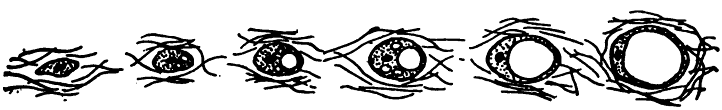


Figure 115. — Growth of a fat cell by the accumulation of drops of oil.

be eaten or secured. How long can a person live without eating? A kind of starch (animal starch) is prepared by the liver and stored in that organ and in muscles. Other foodstuffs are made into fat by the cells of the body and stored in certain cells. These cells grow larger and larger until filled with large drops of fat, as shown in Figure 115.

How Disease Germs Feed in the Body. Sometimes some of the food that is digested in the alimentary canal and made ready for absorption goes to support plants and animals called *parasites*, which get into the body. Such a parasite is the tapeworm, which lives in the intestines see page 138. It has no eyes, limbs, mouth, or digestive organs of any kind; it simply lies in the food substance in the intestines and soaks up the food through the walls of its body, just as a cell of the body does. Besides large parasites like tapeworms, hookworms, etc., there are millions of germs that live in the body. Many

[1] Here are not included the indigestible wastes passed from the small intestine into the large intestine. These wastes are not produced by the cells of the body, never having been absorbed by the villi.

of these are harmless, especially the kinds found in the alimentary canal. Others are very harmful. These, and the harmful effects of their toxins, have already been described.

Why Parasites Thrive in the Body. A moment's reflection will show you why it is that parasites often thrive in our bodies. There are three things living beings need in order to live: food, water, and oxygen. In the body parasites find these things: (1) food in the mouth, the mucous membrane, the stomach and intestines, the blood

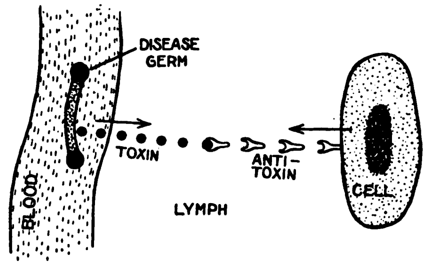


Figure 116. — Diagram to show how a disease germ lives in the blood, taking up food and oxygen (O) and giving off wastes and toxins.

and the cells; (2) water, for seventy-five per cent of the body is water; (3) oxygen, which is constantly being carried from the lungs to the tissues. Most parasites also need warmth, and this we also furnish, for our bodies are always at a temperature of about 98.8° Fahrenheit. No wonder that many kinds of bacteria and other parasites make our bodies their home, for we take so good care of them.

Toxins and Antitoxins. A study of Figure 116 will help us to understand the work of disease germs in the body. Suppose we take a bacterium living in the blood. From the blood it takes food and oxygen and water, and into the blood it pours its waste substances. With the waste substance it gives off poisons called *toxins*. The toxins circulate with the blood and are carried to all the cells of the body, working them injury. A small patch of diphtheria germs in the throat may, for example, give off enough toxins to cause the whole body to become sick. When toxins are present the cells of our body begin at once to produce antitoxins, which pass into the blood and lymph. The antitoxin destroys the toxin and sometimes also the germs, and in this way often protects us against the harmful effects of disease germs.

SUMMARY

The living substance of which the cells of our bodies are composed is called protoplasm. The most wonderful thing this protoplasm can do is to change the food we eat into substance like itself. This process is called assimilation. The cells of the body are surrounded by lymph. Food passes out of the blood capillaries into the lymph and then into the cells, and waste matter passes back into the blood. Disease germs feed in the body just as the cells of the body themselves do. They give off toxins or waste substances, which injure the body. Often the cells of the body give off antitoxins, which destroy the toxins or the germs or both and thus protect us from disease.

QUESTIONS

1. What is the chief work of the blood? 2. Define arteries, capillaries, and veins. 3. In which of these does the blood take on and give off its loads? 4. Why do the capillary walls have to be thin? 5. Does the blood touch all the cells of the body? 6. What is the use of lymph and where is it found? 7. What is assimilation? 8. What is the most wonderful work of protoplasm? 9. Where is protoplasm found? 10. How are waste substances produced? 11. What are the chief wastes made by protoplasm? 12. What foodstuffs are of use in building up the cells? 13. How do wastes get into the blood? 14. What does the blood do with them? 15. Draw Figure 113 on the board and discuss the work of the cells. 16. Show how disease germs feed in the body just as the cells of the body do. 17. How do germs harm the body? 18. What is produced by the cells of the body to counteract the germs of disease?

CHAPTER XXXI. WHY WE BREATHE

Review. In the previous chapters it was pointed out that the cells of the body are continually in need of food and that this food is needed by the cells for growth and repair, to keep them warm, and to enable them to work. It was also shown that it is not the food itself that produces heat, but the burning of the food, or the burning of cell substance itself, that causes us to be warm and enables us to move. We might compare the body to a stove. The stove is not heated merely by laying the wood in it, but by the burning of the wood. To burn the wood, a draft through the stove is necessary; cut off the draft and the fire goes out. This simply means that oxygen from the air is needed to combine with the wood to produce heat. The same is true of the body. What the draft is to the stove the breath is to the body. Oxygen is needed by the cells to burn up the food and to keep up the activities of life; stop breathing, and the body grows cold and life ceases.

In the present chapter we shall see how the air containing the oxygen we need reaches the lungs, how the oxygen gets very close to the blood, and how it is absorbed by the blood so as to be carried where it can be of use to the cells of the body.

How Carbon Dioxid is Produced. In the burning of wood in the stove some of the waste products that result from the burning are given off into the stove pipe and chimney as smoke and gas. Just so the waste products of burning food are given off into the blood and are carried to the organs that throw them off from the body. One of the chief wastes is carbon dioxid. Starch and other foodstuffs contain carbon, and when this is burned the carbon unites with the oxygen to form carbon dioxid.

Respiration Defined. Respiration includes not only the taking in and giving out of air by the lungs, usually called breathing, but also the absorption of oxygen and the giving off of carbon dioxid by the cells of the body. Respiration means, in brief, a taking in of oxygen and a giving off of carbon dioxid. Every cell does this (see Fig. 117); therefore every cell respires. But the cells are so far from the outside world that the blood must carry the oxygen to the cells and the carbon dioxid away from them. In the

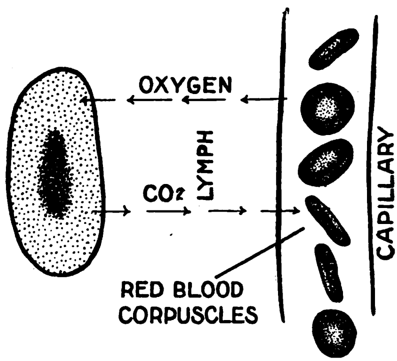


Figure 117. — Diagram illustrating respiration of the cell of the body. CO_2 = carbon dioxid.

earthworm the carbon dioxid is given off and oxygen taken on through the whole skin. In the fish the gills are the organs of respiration. The gills are covered with a thin membrane and filled with blood; it is through this membrane that the fish takes oxygen out of the water and gives off carbon dioxid into the water. In man and the higher animals the air containing oxygen must be taken into the lungs (inspiration) and breathed out again (expiration). While in the lungs the blood takes up oxygen and gives off carbon dioxid. Just how the exchange of carbon dioxid for oxygen takes place through the thin membrane of the lungs and how the blood comes close to this thin membrane, we shall see later.

OBSERVATION AND EXPERIMENTS. (1) Bring earthworms to school and place them in shallow dishes or plates with a little water. Earthworms must be kept moist, for if their skin dries they cannot breathe through it, and therefore they die. Note the red blood vessels that can be seen through the skin of the animals. Why is it that fish and men cannot have skin delicate enough for oxygen to pass through? (2) Keep a goldfish, minnow, or other fish in a clear glass jar of water. Where are the gills of the fish? Note that the water goes into the mouth and out of the gill slits on the side just behind the head. Boys who have strung fish can tell all about this. How does the fish take up oxygen dissolved in water and give off carbon dioxid into the water? (3) Watch your desk-mate breathe; that is, inspire and expire air. Watch him when he is not aware of it and count the number of breathing movements he makes in a minute. (4) Take a short candle and light it. Invert a fruit jar over the candle and note what happens (Fig. 118). Why does the candle go out? Air contains four parts of nitrogen to one part of oxygen. But not all the oxygen can be burned out of the air with a candle, for the candle goes out before all the oxygen is used up. (5) To show more plainly that some of the oxygen disappears, burn a match-head under a quart jar, with the jar inverted over water, as shown in Figure 119. To do this the match must stand upright and be surrounded by an inch or two of water in a broad vessel. The match can be stuck into a block of potato to hold it up. Now, with another match light the match that is to burn out the oxygen from the jar. As soon as the match begins to burn, quickly place the jar over it and into the water. Watch the water rise in the jar. Some of the oxygen has been used up out of the air in the jar, and the water has taken its place (Fig. 119). (6) That expired air contains large quantities of carbon dioxid can be demonstrated easily. Dissolve a little fresh lime (such as masons use to make mortar) in some water and either filter it to get it clear or allow it to stand covered a day or two until the undissolved particles settle to the bottom; then pour off the perfectly clear liquid on top. Now,

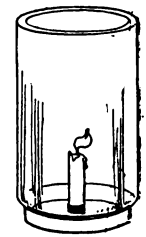


Figure 118.—A candle will go out for lack of oxygen if covered with a jar.

with a straw or a glass tube blow your breath through this clear liquid (Fig. 120). The milky condition of the liquid indicates that carbon dioxid has been added to it.

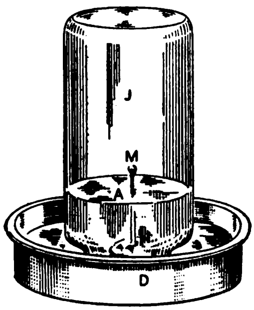


Figure 119.— Burning the oxygen out of a jar (*J*) of air; *M*, match stuck into a piece of potato in a dish (*D*) of water. *A*, level of water after removal of oxygen by burning of match-head.

Figure 120. — Experiment to show that clear lime water made with fresh lime will become milky from carbon dioxid in expired air.

SUMMARY

Respiration is the taking in of oxygen and the giving off of carbon dioxid. The oxygen is taken from the air and is used in the body for oxidation. The oxygen unites with the carbon of our food and tissues, producing carbon dioxid, a waste substance, injurious to the body. Every cell in the body uses oxygen and gives off carbon dioxid. The blood carries the oxygen to the cell and the carbon dioxid away from it. The carbon dioxid leaves the body in the breath, as can easily be seen by experiment.

QUESTIONS

1. Define respiration. 2. How is carbon dioxid formed in the body? 3. In a stove? 4. Why is oxygen needed? 5. Why do we need more oxygen when running than when sitting? 6. What common observation seems to prove this? 7. How does each cell secure oxygen and get rid of carbon dioxid (Figs. 113 and 117)? 8. How does the whole body get rid of carbon dioxid and take on oxygen? 9. How can you prove that about one fifth of air is oxygen? 10. How can you show that carbon dioxid is given off in the breath?

CHAPTER XXXII. THE AIR PASSAGES

In the last chapter it was shown how the cells of the body take oxygen out of the blood and give off carbon dioxid into it. This is called *internal respiration.* In the lungs the blood exchanges carbon dioxid for oxygen with the air that is breathed in and out. The breathing of air in and out of the lungs is called *external respiration.* How external respiration is carried on will be explained in this chapter.

The Breathing Organs. The breathing organs, or the organs of respiration, are the lungs and the air passages carrying the air to and from the lungs. The bones of the chest and the muscles attached to them cause the air to enter the lung through the air passages.

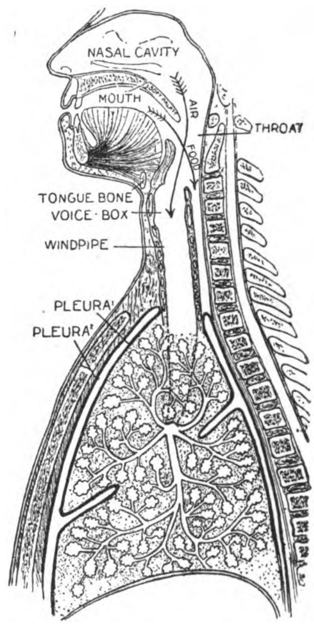


Figure 121. — Diagram of the air passages; arrows show crossing of food and air passages in the throat. Air sacs of lungs and pleuræ shown.

The air passages are the *nasal passages* leading from the nostrils back to the throat or *pharynx*, where the air passage and the food passage cross; the *larynx*, or voice box; and the *trachea*, or windpipe and its branches. The trachea divides opposite the lungs into two bronchi, and these, after entering the lungs, divide into smaller and smaller bronchial tubes or *bronchioles*, as the branches of a tree divide until the smallest twigs are reached. All of these are illustrated in the figures.

The Nasal Passages. The nasal passages are lined with mucous membrane. Here end the nerves of smell, which can detect odors in tiny particles coming in with the air we breathe. We say the nose is the organ of smell. The mucous membrane is, furthermore, richly supplied with blood; and as the passage is very crooked because of passing between and around the irregular bones (Fig. 122) of the skull, the air is warmed as it passes through. The nostrils are guarded by hairs which prevent coarse particles of dust from passing farther into the air passage. Mention two reasons why we should breathe through the nose and not through the mouth. Very often children (and rarely

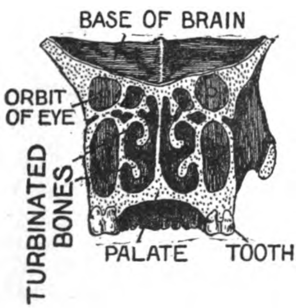


Figure 122. — The turbinated bones, showing the irregular nasal passage in which the air is warmed as it passes through it.

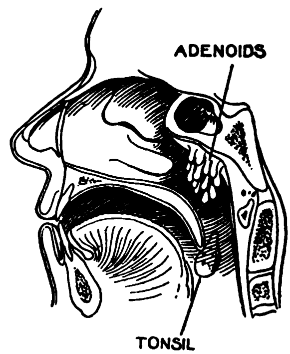


Figure 123. — Adenoids are spongy growths in the nose that tend to stop up the nasal passages. (Compare with Fig. 121.)

grown persons) have spongy growths called *adenoids* just behind the nose (Fig. 123). These growths stop up this passage and force the patient to breathe through the mouth. Children who are mouth breathers are not healthy, and when they attend school they do not do well in their studies. Since a large number of children have adenoids, it is important that all children be examined for nose and throat troubles as early as possible. If adenoids are discovered they should be removed by a physician without delay. The removal of adenoids is a simple operation and affords a wonderful relief to the sufferer.

The Larynx. The larynx or voice box leads off from the pharynx. As the air crosses in the pharynx the path taken by the food (Fig. 121), there is danger of food as well as air going down into the larynx. To prevent this there is a flap, the *epiglottis* (Fig. 127), that fits down over the top of the larynx while swallowing. Point out this organ in Figure 121. The epiglottis itself does not move up and down, but the larynx is pulled up against it in swallowing, as you can readily determine by feeling your throat while swallowing. The larynx is a box of *cartilage tissue*, commonly known as gristle, which is strong and somewhat elastic. The Adam's apple at your throat is the front of the larynx. Feel it and press it.

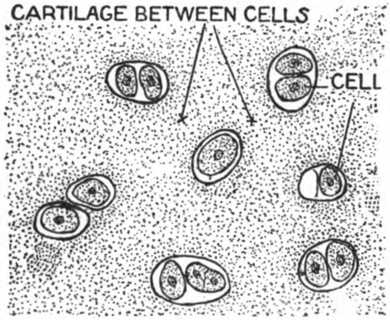


Figure 124. — Cartilage tissue showing the cells and the tough tissue between them.

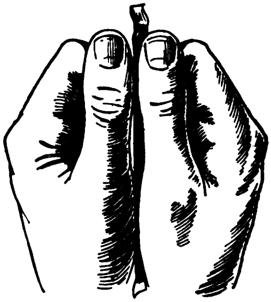


Figure 125. — Diagram to illustrate the vibration of the vocal cords. The breath is blown upon a slip of paper between the thumbs.

The larynx is made largely of cartilage so as to keep the passage always open for the air; for cartilage, while elastic, is stiff enough to support organs. The outer ear and tip of the nose are supported by cartilage. Feel them. If the larynx were made of softer tissue instead of cartilage, what would happen during inspiration? Cartilage tissue, shown in Figure 124, consists of cells with tough and elastic substance between them. It is another of the tissues of the body and finds a variety of uses.

Experiments on the Voice. Take a strip of paper about three fourths of an inch wide and two inches long, or a blade of grass of that size, and place it between the thumbs, as shown in Figure 125, page 189. Now blow hard against the edge of the paper or grass. Stretched across the larynx are two flaps of connective tissue, each of which corresponds to the strip of paper you used in the experiment. (2) To prove that the vocal cords are situated in the larynx, sing a note, and as you sing, alternately press and let go of the Adam's apple. (3) As sound is produced by the vocal cords, the hollows of the throat, mouth, and nose increase it. To illustrate this, hold up a tin bucket horizontally to one side of the mouth and speak into the bucket, noting the effect.

The Trachea and its Lining. The trachea and its branches are simply tubes the walls of which are held open

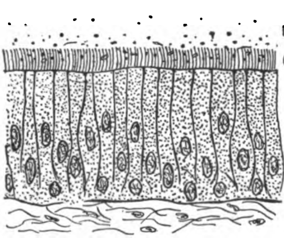


Figure 126. — Ciliated cells of the air passages have it as their duty to sweep dust back into the throat.

by rings of cartilage (*A* and *B*, Fig. 127, page 192). You can feel these rings in the trachea by rubbing the front of the trachea up and down. The breathing tubes are, of course, lined with mucous membrane. The cells of this membrane are peculiar in that they are supplied with tiny hairlike projections called *cilia* (Fig. 126). These cilia stand out from the membrane and are constantly in motion like a field of waving grass.

The cilia act like tiny brushes, sweeping mucous containing fine dust particles out of the lungs toward the throat, where it gathers to be coughed up. In this way nature provides means to keep dust out of the lungs. Of course, if the air passages are overloaded with dust the cilia cannot take care of it all. We should avoid dust. When we are unavoidably in a very dusty place, a handkerchief tied over the nostrils and mouth will keep out most of the dust.

SUMMARY

Respiration consists of internal respiration and external respiration. Internal respiration is the respiration of the cells. The organs of external respiration consist of the air passages and the lungs. Through the air passages the air enters the lungs, being warmed and freed from dust on the way. Hairs in the nose filter out the large particles of dust, and cilia in the air passages sweep finer dust particles back to the throat. But dust should be avoided as much as possible.

QUESTIONS

1. Where does the air enter the body? 2. Where does oxygen get into the blood and carbon dioxid leave it? 3. Name the air passages leading to the lungs. 4. Give reasons why we should breathe through the nose. 5. With a ruler held to your own face, indicate how the skull would have to be cut so that one might see the irregular bones of the nose shown in Figure 122. 6. Where do adenoids sometimes develop? 7. If affected by adenoids, why should we have them removed? 8. Why is cartilage tissue needed in the windpipe and air tubes? 9. How is voice produced? 10. How does the cavity of the mouth and throat help the voice? 11. Point out the cilia in Figure 127. 12. What is the function of the cilia?

CHAPTER XXXIII. THE LUNGS

Review. Study Figures 71 and 73 and the figures in this chapter. How many lungs are there? What is their location with reference to the heart? How are they connected with the bronchi? In what cavity do they lie? What organ do they touch below? How are they and the heart protected from injury?

The Lungs. The lungs are made up largely of air tubes, air spaces, connective tissue, and blood vessels. The air

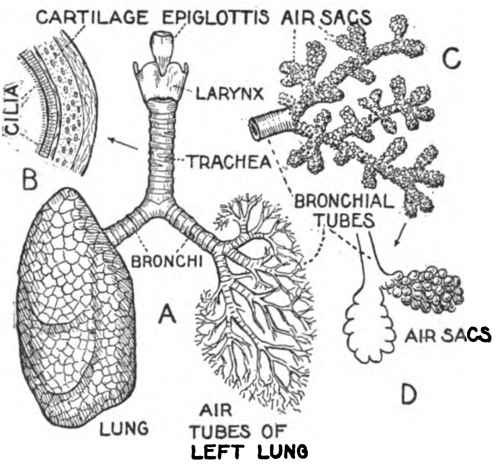


Figure 127. — The lungs and air passages (*A*); *B*, a small part of the trachea or windpipe, magnified, showing cilia and cartilage in the wall; air sacs in upper right hand corner are a portion of *A* enlarged; *D*, the tiniest air sacs still more enlarged.

spaces make them light and spongy, so that they expand and contract readily with each inspiration and expiration. In their movements the lungs rub against each other, against the diaphragm, against the heart, and against the walls of the thorax. To reduce friction they are covered with a double bag, two *pleuræ* (singular *pleura*), between the two layers of which is secreted a liquid, the *pleural* *fluid.* One pleura thus covers the lungs, while the other lines the thorax, as shown in Figure 121. When one's pleuræ become inflamed and hot, one is said to have *pleurisy.*

How we Breathe. We breathe by making the cavity of the chest alternately larger and smaller. When it is

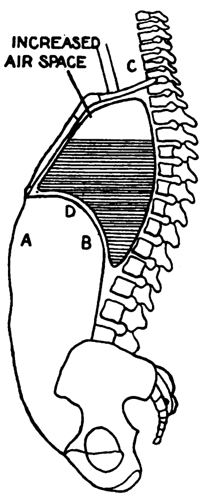


Figure 128. — The chest and abdomen in inspiration. *AB*, horizontal diameter; *CD*, vertical diameter of chest; *D*, diaphragm.

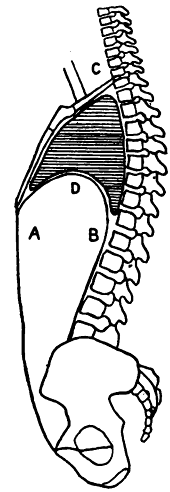


Figure 129. — The chest and abdomen in expiration. *A*, *B* horizontal diameter decreased, *D*, diaphragm elevated by expiration.

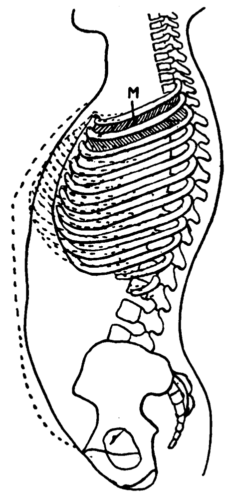


Figure 130. — Inspiration is due partly to the raising of the ribs. Solid lines, position of organs in expiration; dotted lines, in inspiration. Muscles between two of the ribs are shown at *M*.

made larger there is more room for air, and air comes in to fill the space. The question "How we breathe" becomes "How do we make the cavity of the chest larger or smaller?" A study of Figures 128–130 will illustrate the two ways of increasing the capacity of the chest; namely, by raising the ribs and by lowering the diaphragm. This is done by the action of the muscles of the chest and by the contraction of the diaphragm, which is really a large, flat muscle. When the ribs are lowered, the capacity of the chest is lessened and air is forced out of the lungs. Figure 128 shows the ribs raised and the diaphragm lowered in inspiration. Figure 129 shows the ribs lowered and the diaphragm raised in expiration. Figure 130 shows both positions.

The Air Sacs of the Lungs. Thus by breathing movements the air is drawn into the lungs through the air passages. The oxygen finally is carried down into the finest

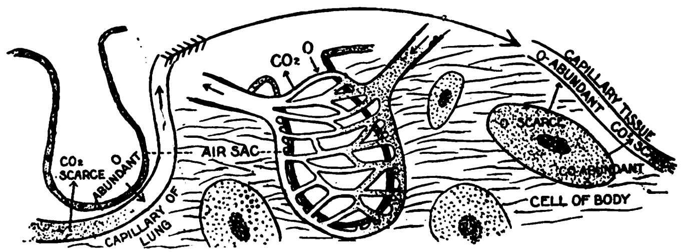


Figure 131.—Diagram illustrating respiration in the air sac of the lung. CO_2=carbon dioxid. O = oxygen.

Figure 132. — An air sac in the lungs, surrounded by blood capillaries.

Figure 133. — Diagram illustrating respiration of a cell at a distance from the lungs.

air tubes (Fig. 127). At the ends of these there are air spaces or *air sacs* surrounded with extremely thin walls; see lower part of Figure 121 and also *C* and *D*, Figure 127. Around the air sacs, very close to these thin walls, are many blood capillaries. Just as the food passes through the villi of the small intestine into the blood, so in the lungs oxygen passes from the air sacs of the lungs into the surrounding blood capillaries and carbon dioxid passes from the blood vessels into the air sacs by diffusion, as indicated in Figure 131. At the cells in other parts of the body the exchange of oxygen for carbon dioxid again takes place, as discussed in chapter XXXI and again shown in the diagram (Fig. 133). The intimate relation of the blood vessels and air sacs is shown in Figure 132.

Hygiene of the Lungs. In *pneumonia*, the disease germs cause an inflammation of the lining of the air sacs. In *asthma*, the smaller bronchial tubes become partially stopped up, rendering it difficult for the patient to get oxygen to the air sacs. How do the germs of pneumonia reach the lungs?

The linings of the air sacs are also injured by *alcohol*. This gets into the blood in the stomach and the intestine and comes out into the breath through the air sacs, as proved by the odor of the drinker's breath. The air sacs become inflamed, and therefore more liable to become diseased and incapacitated for the work they have to do.

The use of *cigarettes* is so injurious that many states have laws against their sale. Their worst damage is to the lungs, for much of the poison in cigarettes is inhaled and reaches the air sacs.

Exercise is an important means of increasing the capacity of the lungs and the power of the chest to expand. Breathing movements or breathing exercises are helpful, but the best way to develop the lungs is by playing vigorous games in the open air.

SUMMARY

The lungs contain the air sacs, or hollows at the ends of the air tubes. The air sacs have very thin walls and are surrounded by meshes of blood capillaries. It is here that the blood gives off the carbon dioxid and takes on the oxygen. The air in the lungs is renewed by the breathing movements of expiration and inspiration, due to the action of the diaphragm and the muscles that raise and lower the ribs. The air sacs may be injured by alcohol and tobacco, the use of which should be avoided. Games in the open air are for most people highly beneficial to the lungs. How to prevent disease germs from harming the respiratory organs is fully treated in the first part of this book.

QUESTIONS

1. How are the lungs protected from injury? 2. What are the pleuræ? 3. How is friction of the lungs against the wall of the chest prevented? 4. *C*, Figure 127, is an enlarged portion of what part of *A*? 5. Similarly, explain the relation of *D* to *C* and *A*. 6. Draw *D*, Figure 127, placing the blood capillaries about it properly (See Fig. 132). 7. Describe how the blood gets rid of carbon dioxid and gives up oxygen. 8. Explain two ways by which we breathe. 9. Explain the meaning of Figures 117 and 133. 10. How are the lungs often injured? 11. Name several diseases of the lungs and air passages, and state in each case how the disease may be avoided.

CHAPTER XXXIV. VENTILATION

How Air is Made Foul. Abundant reasons have already been given why we need oxygen. Outside air consists of about 21 per cent oxygen and about 79 per cent nitrogen, with only a very slight trace of carbon dioxid. But the air expired from our lungs has only 16 per cent of oxygen, 4.4 per cent of carbon dioxid, and some water vapor; the nitrogen remains the same.

Other poisonous matter is given off from the lungs in addition to carbon dioxid. When many persons remain in a room for some time, the organic matter from the lungs, and from the skin as well, makes the air of the room smell bad. The nose, therefore, is a good guide to detect bad air in rooms, provided one has first been in the open air; for after any one has been in foul air for a while, he can no longer detect the bad odor with his nose. In any case, however, he can often tell that the air is bad from his sick and drowsy feeling and headache. Carbon dioxid, organic substances from the lungs and the skin, and disease germs, therefore, poison the air that people breathe. They cause sickness, and, in extreme cases, death.

Ventilation. The foul air about us should be removed constantly. In the open air the wind carries our foul breath away, but we must remove the foul air from the buildings we live and work in and bring in fresh air artificially. This process is called *ventilation*. In what sense is breathing a ventilation of the lungs? Just as we ventilate the lungs, so, if we build houses around us, we must ventilate these houses.

Every person needs 3000 cubic feet of fresh air per hour. On a cold day the air cannot be changed over five times in an hour. Every person should, therefore, be surrounded by 600 cubic feet of space in the room in which he stays. Figure out how far your school room falls short of this standard.

Principles of Ventilation. To supply this fresh air, such buildings as theaters, large churches, office buildings, and some large schools have electric blow-fans that cause drafts of air, previously heated, to blow through the rooms and hallways. But in our homes, and in most churches and schools, we must heat and ventilate without any spe-

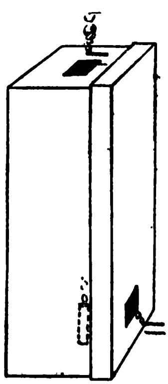


Figure 134. — Experiment with shoe box and candle.

Figure 135. — Experiment to show outgoing current of warm air and incoming current of cold air at a window.

cial fans or airshafts. Ventilation as ordinarily applied with stoves and furnaces depends upon the fact that heated air rises, because it expands, becomes lighter, and is pushed up by cold air coming in from all sides, as can easily be seen from the following experiments:

EXPERIMENTS. (1) Take a common shoe box, set it on end, and cut two holes in it, as shown in Figure 134. Place a lighted candle on the inside. After ventilation has begun, hold a smoldering match or small rag at each hole and note the direction of the current as indicated by the smoke. (2) Now try the same experiment on the school room, if this is heated and the wind is not blowing too hard on the outside. Hold a burning match or a candle at the top of an open doorway or window and then at the bottom, and note the direction of the current in each case (Fig. 135).

Prevention of Draft. From your observations in the experiments with the shoe box and the candle, how would you ventilate by means of windows only? You would lower the top sash and raise the bottom sash. If the stove stands at one end of the room, you should ventilate by the windows nearest the stove. Why?

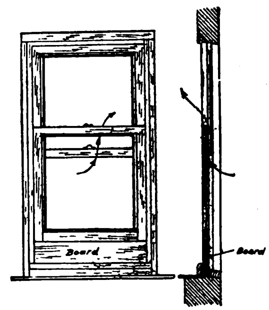


Figure 136. — A simple means of ventilating in very cold weather.

Ventilating by this method is imperfect because the warm air passes out of the top of the window without doing the occupants of the room any good; and the cold air comes in at the bottom, causing a draft. A better way is to leave the top sash in place, raise the lower one, and place a board in front of the open space, as shown in Figure 136.

Ventilation of School Rooms. All these methods may do fairly well for homes during the day, for there are not many persons in a room at a time, and fresh air comes in through the doors, which are opened and closed frequently. For the school room, where thirty to sixty pupils are breathing for some hours at a time, the methods given are absolutely inadequate. It is not too much to say that more children die from the indirect effects of foul air in the school room than from exposure on the way to and from school. There is absolutely no excuse for building a school house that cannot be ventilated properly. The following points should be kept in mind:

1. Heated air rises. The arrows in Figure 137 indicate the directions of air currents. Discuss the ventilation of this school room in class.

2. Fresh air should be furnished, but this should first be warmed. Where should the inlet therefore be? Study

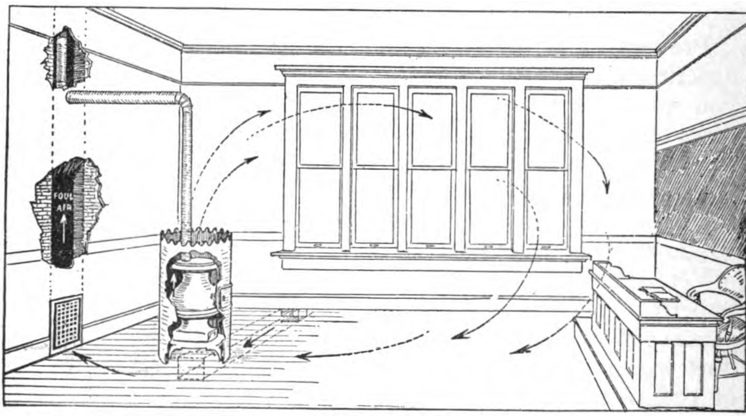


Figure 137.—A schoolroom equipped with jacketed stove and ventilating flue. Arrows indicate direction of air currents. Fresh air comes through a grate in the floor, passes up between the hot stove and the jacket and supplies the room with warm, fresh air. The foul coal air passes through a grate in the wall behind the stove, into the foul-air vent of the chimney and thence to the outside.

Figure 137 and note that the warm fresh air circulates about the room.

3. This warm fresh air should not be allowed to mix with the foul air of the room. The stove should, therefore, be surrounded by an iron jacket reaching to the floor (Fig. 137).

4. There should be an outlet for the foul air. This is in connection with the chimney, which should have two compartments, as shown: one for the smoke, the other for the foul air. The outlet should be near the floor, as it is in the illustration. Why? Draw a picture with an outlet at the top of the room and show by arrows how the air would

pass out. A small fireplace instead of a mere opening is desirable. Other details can be gathered from the picture.[1]

Outdoor Sleeping. Many people in Texas, as well as in all other parts of the civilized world, are sleeping out-of-doors. Indeed, patients suffering from such terrible diseases as tuberculosis and pneumonia are treated by the fresh-air method. If oxygen is good for one who is sick, it ought to be good for one who is healthy. How much time do we spend sleeping each day? How many years in a lifetime of seventy is this? If all this time were spent in fresh air, you can readily see how much healthier we should be. Figure 32 represents a sleeping porch constructed for outdoor sleeping. If any one cannot have this, it is important that one sleep with windows open, of course keeping well covered and avoiding direct drafts.

SUMMARY

The rooms we live in should be well ventilated to keep the air relatively pure. This is almost as important as breathing itself. Where many persons stay in a room for a long time, as pupils in a school room, there should be means of ventilating the room without cold drafts. This is best accomplished by means of a jacketed stove so arranged as to furnish warm fresh air and remove cold foul air continuously.

QUESTIONS

1. Why is oxygen needed by the body? 2. How does expired air differ from inspired air? 3. What are the harmful substances given off by the breath? 4. Define ventilation. 5. How can you tell if your school room is poorly ventilated? 6. Explain Figures 134 and 135. 7. Mention some rules for ventilating an ordinary room. 8. Explain in full the circulation of air in Figure 137. 9. Where does the fresh air come in? 10. Where does the foul air pass out? 11. How is the foul air of the room kept from mixing with the fresh air coming in under the stove? 12. What are the special advantages of sleeping out-of-doors?

[1] Any school board in Texas desiring literature and expert advice on the subject of building school houses may obtain both free by addressing the Department of Extension, University of Texas, or the State Superintendent of Public Instruction, Austin, Texas.

CHAPTER XXXV. THE CIRCULATION OF THE BLOOD

A good deal has already been said about the blood and the lymph and their functions. At this stage of your study, it is perfectly plain to you that the main function of the blood is to carry the useful materials of food and the oxygen to the cells of the body and to take away the harmful waste substances. The blood flows in a system of closed tubes. It is the thinnest and smallest of these, the capillaries, that carry the blood close enough to the cells of the body so that the food and waste substances may be exchanged between the blood and the cell. The lymph surrounding cells and the capillaries together form the medium through which the food and waste materials pass to and from the cells; see Figure 113. Capillaries also come close to the cells of the glands (Fig. 105), the villi (Fig. 110), and the air sacs of the lungs (Fig. 132), as has been shown. In short, the capillaries of the blood come close to each and every living and working cell of the body.

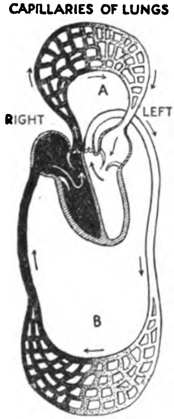


Figure 138. — The lesser circulation (through the lungs) and the greater circulation (through the body).

The Blood as a Carrier. To take on a load of food or oxygen the blood must go to the proper organ to get it, just as your grocer must go to the freight depot to get the groceries before he can supply you with them. The blood is pumped by the heart to the supplying organs: first to the lungs, where it receives its load of oxygen. Here the arteries break up into capillaries which surround the air sacs. Through the thin capillary wall and the thin walls of the air sacs the blood takes in oxygen and gives off carbon dioxid. The purified blood then goes back to the heart to be pumped out again to all parts of the body. In the same way the blood passes through the stomach and the small intestine and takes in food, which is carried by the blood to the heart to be pumped out to all the cells.

The Lesser and the Greater Circulation. It is to be noted that a special trip is made to the lungs; the blood goes to them and then straight back to the heart. This is the *lesser circulation* (Fig. 138). When the blood starts out again from the heart it goes to all parts of the body, passes through the capillaries among the cells, and returns again to the heart. This is the *greater circulation* (Fig. 138).

In short, the heart pumps blood into arteries; these divide again and again into finer and still finer arteries, which finally become capillaries in the lungs and other parts of the body. The capillaries combine to form veins, which return the blood to the heart. The blood is

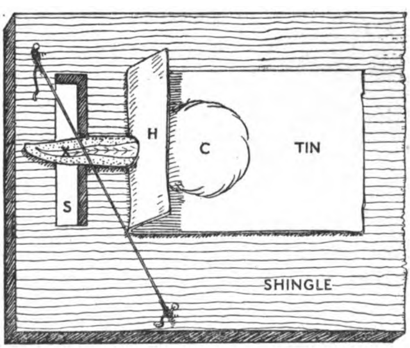


Figure 139. — Showing manner of mounting a tadpole to observe the circulation of blood in arteries, veins, and capillaries. (See p. 204.)

forced out by the pumping action of the heart. It returns partly by this force and partly by other forces, as will be described later.

Observation on the Circulation of the Blood. If you hold your hand up to a bright light, you see the red color plainly through the skin. But you cannot see the blood flow. If you chop a chicken's head off, the blood will run out and the blood will flow, but this is not circulation. Very favorable subjects for studying the circulation are the thin web of a frog's foot and the thin membrane at the sides of the tail of a tadpole. To see the latter a compound microscope is needed. But the sight is so beautiful that it is well worth while to go to some trouble to have a high school teacher or a local physician bring his microscope and show you the sight.

Tadpoles can be found in standing pools of water at almost any season in Texas. Secure one and put it in place, as in Figure 139. To do this the tadpole should be lightly covered with cotton (*C*) kept wet with water. The piece of tin is bent at right angles and has a hole (*H*) through which the tail of the tadpole protrudes. This hole should not be so large as to allow the whole animal to slip through. The tail is laid over the slit (*S*) in the shingle so as to let the light through in viewing a thin part of the tail, as at point *X*, with a microscope. Here the circulation of the blood can be well seen. A thread may be strung over the tail to keep it from flapping during observation. If you are fortunate enough to view this sight, note that the blood flows through the capillaries in a steady stream and not in jerks.

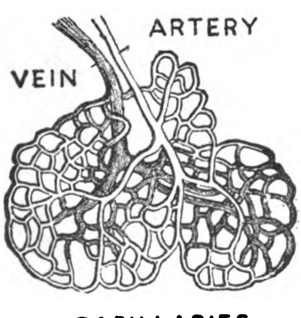


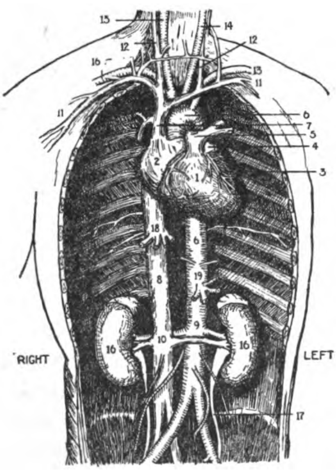
Figure 140. — A network of blood capillaries connecting an artery with a vein.

How the Blood Circulates. The word *circulate* means to travel in a circle. When we say the blood circulates we mean that it continues to return to its starting point. We noted above that this is what happens. The blood is forced on its journey by the heart. From the heart the blood travels in the arteries. These arteries divide into smaller and smaller branches, until the finest hairlike arteries become capillaries (Fig. 140). The blood now starts on its journey back to the heart again. The capillaries combine to form veins, which continue to unite as they proceed to the heart. The blood passes through two sets of capillaries on one complete round through the body: through the capillaries of the lungs, and through the capillaries in different parts of the body, but the blood goes each time to the heart to be pumped out again, as shown in Figure 138. In what sense are there two circulations? In what sense is there really but one complete circulation?

The Heart. The heart has a single duty to perform, and that is to pump blood. It is, therefore, composed largely of muscle and connective tissue. It is located in the thorax, between the lungs, just a little to the left of the middle line, with the point directed to the left (Fig. 73 and Fig. 141). We can feel the beat of the heart between the fifth and sixth ribs. As this organ is in motion a large part of the time, we should expect it to be protected against friction. How are the lungs protected against friction? Name the coverings of the lungs. The heart is in the same way covered by a two-layered bag, the *pericardium*, with a lubricating liquid between the layers.

The heart is divided into two halves by a solid partition wall. No blood can pass from one side of the heart to the other except by going around through the capillaries. The blood must pass through the capillaries of the lungs to go from the right side to the left side, and through other parts of the body in passing from the left to the right side (Fig. 138). Each half of the heart consists of a thin-walled upper chamber called the *auricle*, to receive the blood, and a thick-walled lower chamber called the *ventricle*, to pump the blood out into the arteries. How many chambers has the heart? Name them.

Two large veins bring the blood back to the heart from all parts of the body: the *descending vena cava*, from the upper part of the body (7, Fig. 141), and the *ascending* *vena cava*, from the lower part (8). One ***pulmonary artery*** (5) leaves the right ventricle for the lungs, and four ***pulmonary veins*** (20) carry the blood back to the left auricle. One large artery, the ***aorta*** (6), takes the blood out of the



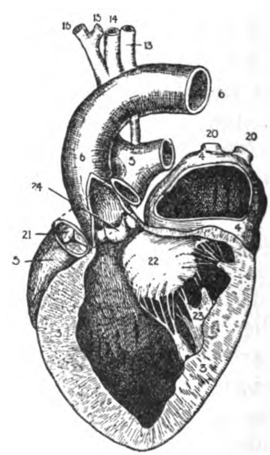


Figure 141. — A view of the principal arteries and veins. 1, right ventricle; 2, right auricle; 3, part of left ventricle; 4, corner of left auricle; 5, pulmonary artery (to lungs); 6, aorta; 7, vena cava, descending; 8, vena cava, ascending; 9, renal artery (to kidney); 10, renal vein (from kidney); 11, right and left subclavian veins; 13 and 16, left and right subclavian arteries; 12, jugular veins; 14 and 15, left and right carotid arteries 18, veins from abdominal organs; 19, arteries to abdominal organs.

Figure 142. — Left side heart, with left ventricle (3) and auricle (4) cut open; 20, two of the four pulmonary veins, from lungs; 21, valves of pulmonary artery (5) almost closed; 24, similar valves of the aorta (6), with part of the aorta cut away; 22, valve between auricle and ventricle; 23, cords and muscles holding the valves.

left ventricle to all parts of the body. How many veins come back to the heart? How many arteries leave the heart?

The Action of the Heart. After the blood has come into both of the auricles, these contract and push the blood into the ventricles. Then the ventricles contract, pushing the blood into the arteries. The contraction of the ven-

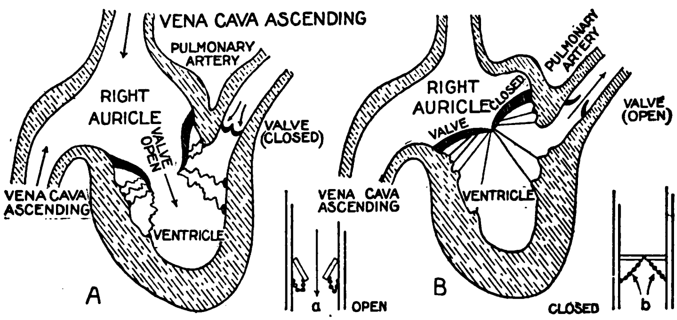
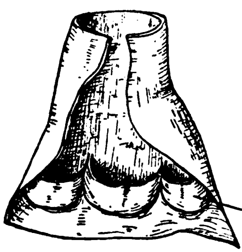
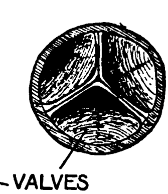


Figure 143. — Diagrams of heart, showing action of valves; *A*, at expansion of heart; *B*, at the beginning of contraction. Diagrams *a* and *b* illustrate action of valves between auricle and ventricle.

tricles constitutes the heart-beat. Since the arteries are already full, pumping more blood into them makes them expand; this expansion is called the *pulse*. Since

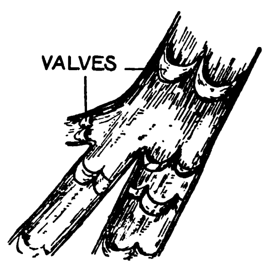


Figure 144.—Valves in aorta. (Compare with Fig. 142, in which part of the aorta is shown cut away.)

Figure 145.—The valves in Fig. 144, closed, as seen from within the aorta.

Figure 146.—A vein with several branches laid open, showing valves that prevent the blood from flowing back.

this happens at every heart-beat, you can count the heart-beat by feeling the pulse. The blood is kept from going back into the auricles from the ventricles by flaps of connective tissue, so placed and held by cords (Fig. 142) that the blood catches under the flaps and closes them after the manner of Figure 143, *B*. This is illustrated further by diagrams *a* and *b* of the same figure. So, too, when the ventricles expand and rest between beats, the blood, under pressure in the arteries, tends to gush into the ventricles. It is kept from returning, however, by pockets fastened to the walls of the arteries (shown at 24 in Fig. 142, and again, more enlarged, in Figs. 144 and 145). Such flaps or pockets that prevent the blood from going in the wrong direction are called *valves*. Point out the valves of the heart in the illustrations, and explain how each acts. How many sets are there?

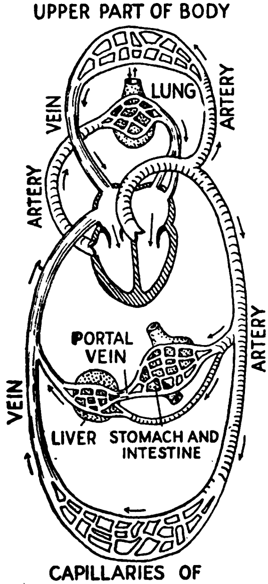


Figure 147. — Diagram of the circulation of the blood. Compare with Figure 138.

Observation Work. (1) Find the pulse on your wrist and count the number of heart-beats per minute. (2) Listen to the heart-beat of some person by pressing your ear against the chest or back on the level of the heart. You will hear two sounds at each beat. These are partially due to the closing of the valves, or as it might be called the slamming of the doors. Which valves close to make the first sound? (Remember that the right and left ventricles contract and expand together.) (3) Study Figures 141 and 147 and trace the blood in a circuit through the body. Trace it from the head back to the head; from the lungs back to the lungs; from the liver back to the liver.

There is one vein that deserves special mention. It is the *portal vein.* It carries proteins and sugar from the small intestine to the liver.

SUMMARY

The blood is the carrying agent of the food to all parts of the body. It is pumped by the heart into the arteries, which branch and gradually become capillaries. The walls of the capillaries are extremely thin, and the blood in the capillaries comes so near the cells of the body that it can give off food to the cells and take on waste products from the cells. Blood is returned to the heart by the veins. The blood passes through the capillaries of the lungs, back to the heart, and through the capillaries of the rest of the body in one complete circulation. The heart consists of four chambers: the right auricle, to receive the blood from all parts of the body; the right ventricle, to pump the blood to the lungs; the left auricle, to receive the blood from the lungs; and the left ventricle, to pump the blood to all parts of the body. Valves are so arranged as to direct the flow of blood in the right direction.

QUESTIONS

1. What is the chief function of the blood? 2. Define artery, vein, and capillary. 3. In which of these blood vessels does the blood come nearest the muscle and gland cells of the body? 4. Why have the capillaries thin walls? 5. What does the blood take up in the lungs? In the small intestine? From the various working cells of the body? 6. What does the blood give off to these cells? 7. What does it give off in the lungs? 8. Name the chambers of the heart. 9. From Figure 143 describe the action of the heart in pumping blood. 10. What is the use of the valves between the auricles and the ventricles? 11. What is the use of those at the openings of the arteries? 12. How many times does the heart beat each minute? 13. Trace the course of blood from the right auricle to the left ventricle. 14. Trace the course of blood around to other parts of the body as the teacher may direct.

CHAPTER XXXVI. THE BLOOD AND THE LYMPH

What the Blood is. We have seen that the blood is the great carrier of the body, taking food and oxygen to the cells and carrying waste matter away. Most of these substances are carried simply in solution, that is in a liquid condition. Blood is largely water containing dissolved substances.

REVIEW WORK. Make a list of all the substances you would expect to find dissolved in the blood.

Blood contains certain cells called *corpuscles: red and white.* They are extremely small; one small drop the size of a pinhead contains several million red corpuscles and many thousands of white ones. The red corpuscles are

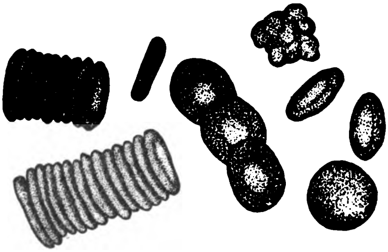


Figure 148. — Blood corpuscles, highly magnified. *A*, red, and *B*, white blood corpuscles.

of the shape shown in Figure 148. The first three in this figure show red corpuscles, highly magnified, in flat view, end view, and oblique view. Describe the shape from the drawings. White corpuscles are shown by the other figures. The blood is easily studied with a large microscope, and this should be done if possible. This sight through the microscope will certainly be a revelation to you, for who would think, after looking at a drop of blood with the naked eye, that it is made up of so many different things?

The Red Blood Corpuscles. The red corpuscles are of just the right size to pass through the capillaries in single file, as can be plainly seen in the tail of the tadpole. Now, when you are told that it is the duty of these little cells to carry oxygen from the air sacs of the lungs, you will readily see why they must pass in single file. At a circus the crowd passes in single file by the ticket window to get the tickets, and each person deposits his ticket at the entrance. Copy Figures 131 and 133, and add to your drawing red corpuscles in the capillaries.

How the Red Blood Corpuscles Carry Oxygen. Just how the corpuscles carry oxygen is not easy to understand. Oxygen in the air is a gas, and in that condition a little oxygen takes up a great deal of room. The oxygen makes itself small by uniting with a substance called *hemoglobin*, which is found in the red blood corpuscles. When there is much oxygen present, as in the air sacs of the lungs (Fig. 131), the hemoglobin causes the oxygen to unite with it, and in this condition the oxygen takes up almost no room. But the oxygen will easily let go of the hemoglobin when the blood reaches a place where oxygen is scarce, as it is out among the working cells of the body (Fig. 133).

The White Blood Corpuscles. The white corpuscles differ from the red ones for they can change their shape,

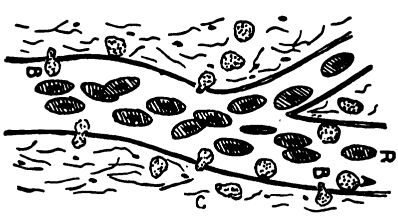


Figure 149.—Blood vessel of frog, showing how white blood corpuscles pass out of the blood vessel. *A*, corpuscle within the vessel; *B*, partly, and *C*, entirely outside the vessel. *R*, red corpuscle.

and they have also quite a different work to do. They are the soldiers and scavengers of the body. What is a soldier's duty? A scavenger's? The white corpuscles fight for us, swallowing and digesting the disease germs of the body (Fig. 12, page 16). They also take up fragments of worn-out protoplasm among the cells. If you stick a splinter in your finger, the white corpuscles travel to the spot and try to surround the splinter and protect the body. These corpuscles can get out of the capillaries by squeezing through them between the cells, just as you would squeeze a large-sized rubber ball through a small crack in a fence (Fig. 149).

Where the Corpuscles are Produced. Both kinds of corpuscles are continually being worn out and new ones produced. The red ones are made by certain cells in the red marrow of flat bones and in the spleen; the white ones by certain cells in the spleen and lymph glands.

What happens to the body if we have too few white blood corpuscles? What do the cells lack if the blood has too few red ones? If the red ones are scarce in the blood of a person, he is said to suffer with *anemia*. In malarial fever the germs destroy the red corpuscles. A patient suffering with this disease is anemic and shows it by a pale or sallow complexion. Hookworm patients, too, are anemic, owing to the loss of blood that is sucked from the wall of the intestines by the worms. It is important that we should do everything to help the body produce many corpuscles. Plenty of fresh air, good food, sleep, and exercise are conducive to the production of blood corpuscles.

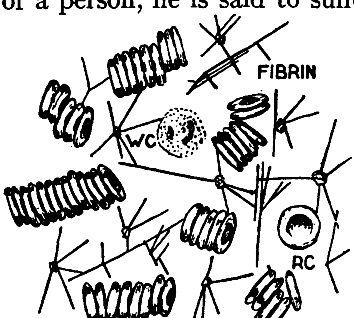


Figure 150.—A bit of blood clotted, showing fibrin strands; *RC*, red, and *WC*, white blood corpuscles.

Clotting of Blood. How does the blood act when it runs out of a cut or other wound? It clots, you say.

This is due to the strands of *fibrin* that the blood contains. (Fig. 150). Fibrin is a kind of protein, which separates out or coagulates, just as the white of an egg, another kind of protein, coagulates when it is heated. There is a protein in the blood that coagulates and changes to fibrin when it is exposed to the air.

Observation Work. Leave a bottle at the butcher's and ask him to have it filled with ox blood.

When you call for the bottle and take it to school, a dark red clot will have formed (Fig. 151). Of what does this clot consist? The straw-colored liquid on top is serum; this contains water, foodstuffs, and wastes in solution. It also contains antitoxins when these are present in the blood (Fig. 116).

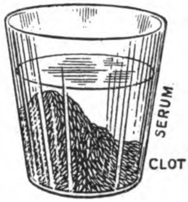


Figure 151.—A tumbler of clotted blood.

The Lymph. There is another fluid in the body very much like the blood; namely, the lymph. Read again what has been said of lymph and describe where it is found. Lymph differs from the blood, for it lacks red blood corpuscles and clots more slowly than the blood does. Perhaps you remember when you last had a blister from a burn. The blister was filled with thin lymph. The fluids contained in the pericardium, between the pleuræ, and around the abdominal organs are kinds of lymph.

After studying Figure 113 you will understand that the function of the lymph is to fill the spaces among the cells of the body and to form the means of communication between the cells and capillaries. Which substances are given to and which taken from the cells in Figure 113? A little thought will also tell you where all the lymph probably comes from: it oozes out of the blood capillaries and is, we might say, the liquid part of the blood. The cells also add their waste substances to the lymph. The lymph helps the blood to carry off these waste substances.

The Lymphatics. Now the lymph must be constantly renewed and therefore constantly drawn off. It does not pass back into the blood directly, but it has vessels of its own, the *lymph capillaries* and *lymph veins*, that carry the

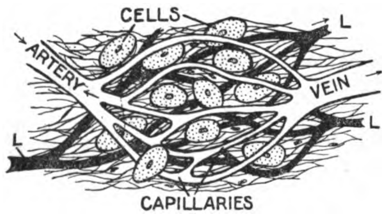


Figure 152. — Lymphatic capillaries (*L*) beginning in the lymph spaces among cells of the body.

lymph away. The lymph capillaries start in the lymph spaces (Fig. 152) and unite into veins just as the blood capillaries do. The lymph veins all finally unite in two large lymphatic ducts, the larger of which, on the left side, is called the *thoracic duct*. Figure 153 shows where the two ducts are situated. Note that they empty into large veins above the heart, where the lymph again mixes with the blood. The liquid portion of the blood that comes out of the capillaries thus runs back into the blood.

There is another special starting point for the lymph. Review what was said about the lacteals and tell where they are and what these lymph vessels carry into the blood. The lacteals unite and empty into the thoracic duct (Figs. 111 and 153).

Lymph Glands. On their way the lymph tubes pass through knots of spongy tissue, called *lymph glands*, or *lymph nodes*. Here certain changes occur in the lymph; disease germs are stopped here and kept from going into the blood. The lymph glands also produce corpuscles, as mentioned above. The spleen is a large gland very much like lymph glands. Figure 153 shows the location of some of the lymph glands of the body. Figure 154 represents a single one cut open. Note that the lymph vessels have cross lines on them. These show where are the valves, the use of which is exactly that of the valves in the

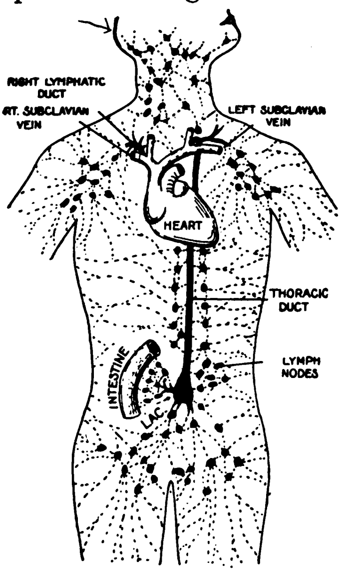


Figure 153. — The lymphatic system. *LAC*, lacteals.

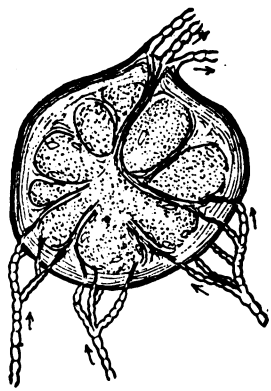


Figure 154. — A lymph node, with lymph vessels.

veins. How blood is forced along in the veins and lymph in the lymph vessels will be described in the next chapter.

SUMMARY

The blood contains red and white corpuscles. The red blood corpuscles have to do with interior respiration, for they carry oxygen from the lungs to the cells of the body. The white corpuscles have to do with the fighting of disease germs in the body. The number of both kinds of corpuscles is increased by correct habits of living. The blood also contains a protein that forms fibers of fibrin, which cause the blood to clot. The lymph surrounds the cells of the body. It is moved along and collected in lymph vessels, which empty into the blood vessels above the heart.

QUESTIONS

1. What have the red corpuscles to do with respiration? 2. What is the work of the white corpuscles? 3. In what organ of the body is each kind of corpuscle made? 4. What is anemia? 5. How do hookworm and malaria cause anemia? 6. What is the value of the clotting of blood? 7. What is serum? 8. What parts of the blood does the clot (Fig. 151) contain? 9. Where is lymph found in the body? 10. Describe a lymph vessel. 11. Is it more like a vein or more like an artery? Why? 12. What does the thoracic duct carry? 13. Where does it empty its contents? 14. What are the lymph glands? 15. How does exercise help the flow of lymph?

CHAPTER XXXVII. HYGIENE OF THE CIRCULATION

Differences between Arteries and Veins. Arteries and veins differ, as has been seen, in the direction in which the blood flows in them. In which does the blood flow away from the heart? They differ also in the thickness of their walls (Fig. 155). The veins have less elastic connective

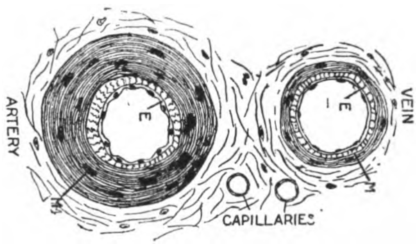


Figure 155. — Cross section of artery, vein, and two capillaries. *L*, epithelial lining (the only tissue in the capillaries); *M*, muscle tissue; *C*, connective tissue.

tissue and muscle than the arteries. The veins, furthermore, have valves throughout their course, as shown in Figure 146. Where are the only valves in the arteries?

In the arteries the blood is under pressure. When an artery is cut, therefore, the wound stands open, blood spurts out, and a person is in great danger of bleeding to death. The arteries are protected by being placed deeper under the skin and muscles than the veins. When an artery is cut, pressure should be applied between the cut and the heart, to stop the bleeding, as will be described in Chapter LVIII.

How the Blood Gets Back to the Heart. Contraction of the heart is the main force that sends the blood coursing toward the capillaries, where the blood does its main work. Now, let us see how the blood is forced back to the heart. First, the pressure from the arteries pushes the blood through the capillaries into the veins. Second, the blood is sucked toward the heart. The suction occurs in the chest when we breathe in air. Third, the blood is squeezed on its way toward the heart every time any muscle contracts. When the muscle becomes hard and firm it presses against the blood vessels and thus tends to drive the blood out of them. To prevent the blood from flowing away from the heart, there are valves all along the veins, set as illustrated in the diagrams (Figs. 156 and 157). The suction action of breathing and the contraction of the muscles force the lymph along exactly as the blood is forced along the veins.

Observation Work. You can easily locate the valves in a vein on the back of your hand or on your wrist. Hold your

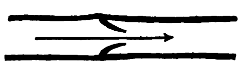


Figure 156. — Valves in vein, open.

Figure 157. — Valves in vein, closed.

hand down and press the muscles of your forearm on the edge of the desk. This will make the veins of the back of your hand stand out. Now, with the blunt end of your pencil, press along a vein toward the fingers (away from the heart) and note that the vein does not fill from the end toward the heart.

How Exercise Helps the Circulation. From what has been said in this chapter it stands to reason that exercise improves the circulation in a number of ways:

First, exercise causes a stronger beating of the heart, which strengthens this organ as it does any other muscle. We should take enough exercise every day to make the heart beat strongly for a while. Such exercise will enable the heart to endure hard work.

Second, exercise causes deep breathing, which increases the suction of the blood and lymph toward the heart.

Third, exercise helps the flow of blood through the muscles. That is the reason why muscles that are used a great deal are darker than others.[1] Since it is hardest for the blood to pass back to the heart from the lower limbs, walking and running are very important forms of exercise. It should also be noted that rubbing a part of the body helps to improve the circulation of the blood and the lymph.

Experiment to Show the Effect of Exercise on the Heart. Count the pulse after you have remained quiet for fifteen minutes. Stand up and after one minute count the pulse; walk a minute and count again; run or hop a minute and make another count. Why does exercise make the heart beat faster? Review previous lessons before trying to answer fully.

Overexercise. While it is true that the heart should beat strongly for a while each day, we must guard against too severe exercise, such as boys and girls in the grammar grades are likely to indulge in. At this age the heart grows very fast. The valves of the heart have not grown strong enough to stand the great pressure which its too vigorous beating may cause. Foot-racing, bicycle riding, football, and even tennis may easily be overdone. Grammar school boys should not attempt to run more than a fifty-yard dash or a quarter-mile relay race.

Changes in the Quantity of Blood in the Arteries. You have noticed that after exercise your skin is red. This shows that more blood has been sent to the skin. When the body is warm, the skin is red; when the body is cold, the skin is pale. Embarrassment often causes blushing, and fear causes pallor. These are examples of change in the quantity of blood that is sent to the skin. Now the quantity of blood in an organ at any time depends upon the size of the blood vessels in that organ. When the arteries of the skin are expanded, they allow more blood to come in, and this is shown in the redder color of the skin after exercise and when one is embarrassed.

[1] Compare, for example, the breast and the leg muscles of a chicken.

Alcohol. Alcohol causes the blood vessels of the skin to enlarge. For this reason a person feels warmer after a drink of whisky and some people think that this warmth is real. Since there is more blood in the skin, however, the actual effect is that the body cools off faster. It is, therefore, a mistake to take whisky when starting out on a trip in cold weather. No one who uses alcohol could ever reach the North or the South Pole. A good quantity of fuel food and not alcohol is the real producer of heat and energy in the body.

Other Effects of Alcohol on the Circulation. Alcohol makes the heart beat faster and so interferes with nature's way of regulating the beat. The heart is thus overworked. It is said that alcohol in small quantities makes a person fat. But this fat is unhealthy, and if the fat is deposited about the heart, it becomes dangerous. Many deaths occur from diseases, because the heart fails to do its duty. This is specially true of pneumonia. You have heard it said of a sick person, "Tomorrow will come a turning point in the disease," or "If he lives until tomorrow he will get well." How necessary it sometimes is to have a heart that will hold out just one day longer! We cannot afford to do anything that will injure this wonderful organ, the heart.

Tobacco. Doctors speak of an "alcohol heart" and a "tobacco heart": an unsteady, palpitating, fluttering, unreliable heart. Tobacco is particularly harmful to the young boy of grammar or high school age. At that time the heart grows rapidly and any interference with its proper development is sure to lead to permanent injury.

SUMMARY

Arteries are not as easily cut as veins, because they lie deeper under the skin and muscles; but when cut it is more difficult to stop them from bleeding, since the blood in them is under pressure. Blood is returned through the veins to the heart by pressure transferred through the capillaries from the arteries by the sucking action of the breathing movements and by the squeezing action of the muscles of the body during exercise. The valves all along the veins keep the blood from flowing backward. The lymph is forced on its way by similar means. Exercise is necessary to the proper circulation of the blood and lymph, and to the strengthening of the heart. Alcohol has a decidedly harmful effect because it causes a faster beating of the heart and an increased flow of blood to the skin when these things are not necessary. Tobacco causes interference with the nervous control of the heart-beat.

QUESTIONS

1. Name some of the differences between veins and arteries. 2. Where should pressure be applied to stop bleeding from an artery that is cut? 3. How does deep breathing help the circulation? 4. Discuss the action of valves in the veins. 5. How does exercise help the flow of blood? 6. How does exercise strengthen the heart? 7. What is the danger of overexercise? 8. How does alcohol injure the heart? Tobacco? 9. Why does alcohol really cause the body to lose heat?

CHAPTER XXXVIII. EXCRETION

The Meaning of Excretion. We have thus far considered a number of activities of living cells: the taking of food, assimilation, growth, respiration, and other activities. You should be able to tell in your own words what each of these means. Digestion, absorption, assimilation, and growth are all building-up processes, which end in the making of protoplasm by the cells of the body. Then oxygen comes to the cell and burns up the protoplasm and the foods, and thus tears down or breaks up the protoplasm. Oxidation is a tearing-down process, but it is necessary in order that energy for warmth and motion may be produced.

Oxidation not only produces energy, but also forms waste substances. The production of waste substances is called *excretion*. Every cell excretes waste substances (Fig. 113), and the blood carries them to the organs by which they are removed. The organs that remove waste substances from the blood are called *excretory organs*.

The Waste Materials of the Cell. We have already studied one set of excretory organs,[1] the lungs, which remove carbon dioxid from the body. Respiration thus includes two phases: the taking in of oxygen and the removing of carbon dioxid (Fig. 117). The lungs are, therefore, in a sense, organs of excretion which remove most of the used-up carbon from the body.

Another important waste substance is that containing nitrogen and is called *urea*. This is removed by the kidneys and by the sweat glands of the skin.

Thus it is seen that there are two main kinds of waste substances: carbon dioxid, which contains most of the carbon and is removed from the blood by the *lungs;* and urea, which contains all the nitrogen and is removed from the blood by the *kidneys* and skin.

[1] We shall not include here the large intestine, which removes indigestible and undigested foods, unabsorbed portions of the digestive juices, and bacteria from the alimentary canal. It is, of course, of extreme importance to health that decaying remnants of the food should be removed daily from the body.

The *liver* is sometimes included with the excretory organs, but this is only partly correct. The liver does not remove waste substances, but changes them to a form that is more easily removed by the kidneys and skin.

The Kidneys. The situation and shape of the two kidneys can be seen in Figure 71; also at 16, in Figure

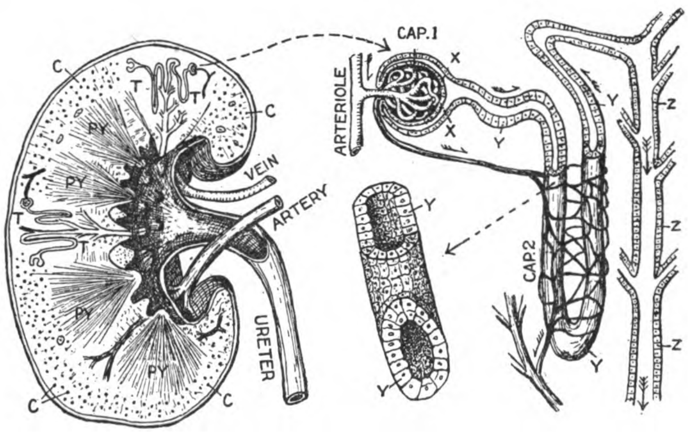


Figure 158. — Vertical section of a kidney; *H*, hollow of kidney, communicating with ureter. *T*, tubules (much enlarged) beginning in pockets and emptying in hollow, *H*. *PY*, masses of tubules beginning in pockets in region *C*.

Figure 159. — Tubule and pocket of kidney, much enlarged; *X*, epithelial tissue of pocket, *Y* and *Z* of tubule. Cap. *1*, blood capillaries of pocket; Cap. *2*, capillaries of tubule.

Figure 160. — A portion of tubule much more enlarged. *Y*, cells of tubule.

141. Figure 158 represents one kidney, opened, showing the internal structure. As the urea is carried to the kidney by the blood there are, as we would expect, a large artery (renal artery) leading to the organ, and a large vein (renal vein) carrying the blood away (9 and 10, Fig. 141). Which of these, artery or vein, has the smaller amount of impurities in it? So you see that arteries do not always carry

purer blood than the corresponding vein. Give another example of this occurrence.

Structure of the Kidney. The kidney is made up of a very large number of fine tubes or tubules that begin near the outer surface as little pockets of epithelial tissue. The pockets are indicated in the figure by dots (*C*, Fig. 158) and the tubules by lines (*P Y*). These tubules pass toward the hollow of the kidney at *H*. Four tubules, enlarged, are shown at *T* in the same figure, two near the top and two near the middle of the section represented. From Figure 160 the course of the capillaries of the blood can be seen. A bunch of capillaries (Cap. *1*) enters the pocket at the head of the tubule itself (Cap. *2*). The cells that take water and waste substances out of the blood are the cells shown at *X*, *Y*, and *Z*. The kidney is in a sense a gland. By comparing Figure 160 (a part of a tubule much magnified) with the gland shown in Figure 106, you may easily see how much the tubule of the kidney is like a gland. We have here another example of the close relation of working cells to the blood capillaries. The waste substances here removed by the kidney cells are emptied into the hollow of the kidney at *H*, Figure 158, thence through the ureter into the bladder.

Hygiene of the Kidneys. There are not many points to be remembered in the hygiene of the kidneys. A large percentage of the kidney diseases that occur are due indirectly to germ diseases such as scarlet fever and diphtheria. The kidneys have to filter out the poisons which the germs form in our bodies, and this work is damaging to the kidney cells (*X*, *Y*, and *Z*, Fig. 160). The best way to take care of the kidneys is to take care of the body itself

It is wise to drink a great deal of water at all times, as this dilutes the poisons which are thrown off by the kidneys. It seems reasonable to believe that all irritating substances which pass out through the kidneys, like alcohol and the oils from hot condiments and spices, such as mustard or horse radish, will irritate the kidneys and in the long run damage them. Fried food contains certain irritating substances which are the result of the burning of the grease, and these substances must be thrown off by the kidneys. Lastly, sudden and extreme changes in temperature may injure the kidneys.

SUMMARY

The pair of kidneys are the chief excretory organs of the body for the removal of urea. They are richly supplied with blood vessels. A study of the finer structure of the kidneys shows them to be true glands, for the capillaries of the blood enter pockets of gland tissue and surround tubules of the same kind of tissue. The gland cells take the waste material out of the blood and pass it on to larger tubes emptying into the hollow of the kidney. Alcohol and toxins of disease germs are especially injurious to the gland cells of these organs.

QUESTIONS

1. Why do the cells of the body form waste substances? 2. Name the two chief kinds of waste substances produced and the organs that remove them from the blood. 3. Why has the renal vein purer blood than the renal artery? 4. What cells in Figure 160 take waste substances out of the blood? 5. In what regard are the pocket and tubule (Fig. 160) like glands shown in Figure 105?

CHAPTER XXXIX. THE SKIN

Description of the Skin. The skin is a double covering of the body. The thinner outer skin, the scarf-skin or *epidermis* (Fig. 161), is made up of dead, flattened cells, with the exception of the lowest layer. This lowest layer produces the cells in the outer layer of the skin as fast as

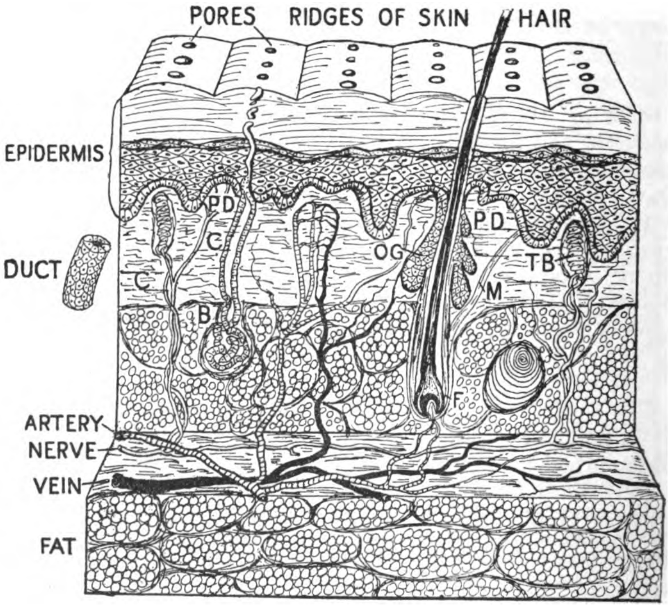


Figure 161.—A block of skin about the size of a small grain of corn, magnified. All below the living layer of epidermis is dermis, *PD*, papillæ of dermis; *TB*, touch buds in papilla; *B*, coil of sweat glands; *F*, hair follicle; *OG*, oil glands; *M*, muscle of hair; *C*, connective tissue of dermis. To left, duct of sweat gland, much enlarged.

they are ordinarily worn away. The epidermis contains few nerves and no blood vessels.

The inner or true skin, the *dermis*, is made largely of connective tissue (*C*); this is, therefore, the part of the skin of animals that is made into leather. It is richly supplied with blood vessels and there are many fat cells scattered through it. The fat helps to keep animals warm; the whale, for example, has a thick layer of fat under the skin so as to keep warm in the icy waters of the cold seas.

The skin is the organ of touch. It contains nerves that end in certain cells placed where the dermis projects up into the epidermis; these projections, or *papillæ*, contain the nerves of touch with which we feel things, — that is, distinguish hard and soft, wet and dry, sharp and dull, etc. With other nerves in the skin we distinguish heat and cold.

The blood vessels in the skin perform their usual duty of serving the wants of the living cells. They must, in the first place, bring material with which the living layer of the epidermis can grow and multiply and produce more cells to take the place of those that wear off. The mass of cells worn off in the course of a year would, if they could be collected, fill a basket of considerable size. Dandruff is simply masses of skin cells from the scalp. To furnish materials to renew the worn-off cells, the blood comes through the dermis close to the living layer of the epidermis. (Compare Fig. 161; also *C*, Fig. 211). The blood also carries material for the hair and the sweat glands, that reach down from the epidermis into the dermis.

The Hair. The hair is made up of the same substance as the epidermis; indeed, it is produced by epidermal cells that extend down into the dermis like a kind of socket. In this socket, called the *hair follicle* (*F*, Fig. 161), the root of hair stands. At the bottom of the follicle is a mass of cells that grow and multiply rapidly, adding to the hair and pushing it out as it grows. Hair thus grows from the bottom, or "root," which is richly supplied with blood. Hair has attached to it two organs; first, a muscle (*M*), which by contracting can make the hair stand on end. A dog or a cat when angry uses these muscles to make the hairs on its back stand up. Each hair is also provided with one or more oil glands (*OG*), which empty oil into the hair follicle. You have noticed how a leather harness cracks and breaks when not kept oiled; the skin and hair, too, must be oiled to keep them fresh and pliable.

The Nails. The finger nails and the toe nails are also horny like the epidermis, but they are much more thick. They are produced from cells at the base or root of the nail, and are pushed forward as they grow (Fig. 162). The nails should be trimmed even with the fingers, but no farther. Dirt that collects under the nail should be removed with a dull instrument, — not with a sharp knife, for this roughens the under surface of the nail and makes dirt gather still more easily. Stains on the surface may often be removed with vinegar.

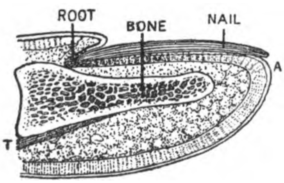


Figure 162. — Longitudinal section of end-joint of finger.

Structure of the Sweat Glands. Other extremely important organs of the skin are the sweat glands. These are simply tubes running down from the surface, through the epidermis, and for some distance into the dermis. They are coiled up at their lower ends. The coil (*B*, Fig. 161) is surrounded by a network of blood capillaries as seen in diagram 5, Figure 105, and again in Figure 163. The epithelial tissue of the sweat gland comes in close contact with blood capillaries, as is the case with all glands. The sweat gland is coiled up in the dermis (*B*) because it is so long; there would not be room in the skin if all the sweat glands were stretched out straight. The sweat glands are long so that there may be much surface for excreting.

Functions of the Sweat Glands. The sweat glands remove from the blood sweat or perspiration, which consists of water with salt and some waste substances dissolved in the water. They are thus in part excretory, and each sweat gland may be compared to a single tubule of the kidney. Compare Duct, Figure 161, with Figure 159. How is a sweat gland similar to a tubule of the kidney in structure? But excretion is not the chief function of the sweat glands, for the perspiration is of great use to the body in helping to keep it from getting too hot, as will be explained below. Each gland [1] opens on the surface of the skin by a *pore* (Fig. 161).

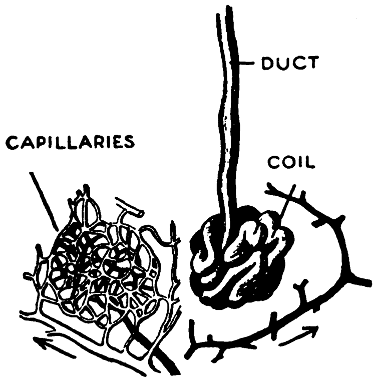


Figure 163. — Coiled end of sweat gland; the network of capillaries removed from its natural position around the coil. (Compare with 5, Figure 105, and *B*, Fig. 161.)

Hygiene of the Skin. The skin must be frequently washed to keep it clean. Dirt, disease germs, the solid substances dissolved in sweat, dead epidermal cells, and oils are continuously being given off by the skin. Good pure soap should be used in washing, for soap dissolves oil by breaking it up into tiny particles. The ease with which grease is removed by soap is familiar to every one. Soap is a good disinfectant and should be used for this reason also.

[1] The number of sweat glands in the adult has been estimated at 2,500,000.

Wounds. Disease germs cannot easily get into the blood through the unbroken skin. Hookworm larvæ on the bare feet of children get into the blood vessels of the dermis by way of the hair follicles. Lockjaw germs usually live in the soil, especially around horse lots, they may, if present on the skin, be driven into and under the skin by a nail (Figs. 239–241) or a piece of firecracker or a cap of a toy pistol. When this happens a person may have lockjaw and die. If the skin is wounded and the blood runs freely and then dries well over the wound, remove the excess of blood with a dry, clean white cloth and tie the wound up without washing, for blood itself is a good cleanser. But if the wound is open, and dirt and bacteria are likely to get in, the wound should be washed with a disinfecting solution and bound up in a clean white cloth.

Warts and Moles. Oftentimes you have noticed on the skin little tumors known as warts or moles. The warts are usually only temporary and harmless. The moles are usually harmless also, but may last a lifetime. Either wart or mole may degenerate or change into a dangerous tumor like a cancer, especially if it is in an exposed place where it is likely to be irritated. For this reason these warts or moles should not be allowed to become irritated. If they are in a place where irritation cannot be prevented, they should be thoroughly removed by a physician. Any sign of inflammation in a mole should be heeded, as it sometimes takes on a rapid growth.

Pimples. All young people are interested in having a good complexion, and without doubt pimples on the face are the commonest cause of poor complexions. We do not know all the facts as to the cause of these pimples, and until we do we cannot do much toward preventing them. After the pimples appear, they are usually slow and stubborn to leave; but patience and care will drive them away. The problem of how to get rid of them is too difficult to explain here, but it is best to make it a rule to get the entire body in as perfect health as possible, and not try to any plans of cure except those recommended by reliable persons.

SUMMARY

The skin consists of a thin outer layer, the epidermis, and a thicker inner layer, the dermis. The dermis is well furnished with blood vessels, which supply the sweat glands and the growing cells of the epidermis, the hair, and other organs of the skin. The functions of the skin may be summarized as follows:

1. To form the covering for the body. (Both layers.)
2. To protect the more delicate parts (a) from injury and (b) from disease germs. (Epidermis, hair, and nails.)
3. To excrete waste. (Sweat glands.)
4. To cool the body. (Sweat glands.)
5. To act as the organ of touch. (Touch buds and nerves.)

QUESTIONS

1. What are the functions of the skin? 2. Name the organs found in the skin. 3. Point out (Figure 161) the living cells of the epidermis? 4. Wherein do the dermis and epidermis differ? 5. With Figure 161 before you, describe the skin. 6. Describe a hair. 7. Why do blood capillaries come close to the root of the hair? 8. To what part of a kidney does Duct (Figure 161) correspond? 9. Wherein are the tubule of a kidney and a sweat gland alike? 10. Why may warts or moles become dangerous? 11. How should we treat an open wound in the skin? 12. A closed wound, as a nail thrust?

CHAPTER XL. THE REGULATION OF HEAT IN THE BODY

If the temperature of a healthy person is taken, winter or summer, day or night, at rest or at work, it is always found to be near 98.6° Fahrenheit. The body is constantly giving off heat into the surrounding atmosphere. To make good this loss, foodstuffs are burned or oxidized in the body. The temperature of the body is the balance between the heat formed in the body and the heat lost. We have previously studied the use of food and oxygen in causing heat in the body. In this chapter we shall discuss how the body-engine is kept from becoming too hot or growing too cold.

Distribution of Heat in the Body. When heat is produced by exercising a muscle in one part of the body, the whole body becomes warmer. For example, if you work the right arm you will soon feel warm all over. If the extra heat is produced only in the arm, why does the arm not become hot? Why do all parts of the body feel warmer? The blood distributes heat over the body, drawing it away from the part being exercised. *The blood, therefore, carries away from the working cells not only waste material, but also heat.*

It is now easy to answer the question, "What does the blood do with the heat brought away from the muscle cells?" The heat is carried to the skin, where the body comes in contact with the outside world. Here the heat leaves the body and passes into the surrounding air. This occurs all the time, but faster in cold than in warm weather. In winter, therefore, more heat must be generated by oxidation; for that reason it is well to eat more fats in the cold season. Alcohol is of no use and is positively harmful when taken for the purpose of increasing body heat.

How the Body Gets Rid of Excessive Heat. During exercise the body must use special means of getting rid of excessive heat. Note the color of the faces of boys and girls coming in after recess from a frolic on the playground.

Their faces are flushed because more blood flows into the skin. This is brought about in the following manner:

In the arteries of the skin, as in all arteries, there are muscles and nerves. When the muscles contract the artery becomes smaller and contains less blood. When they relax, the artery is dilated (made larger) and more blood rushes into the blood vessel. Heat stimulates the nerves that make the arteries expand. Therefore, when the body is warm the skin is red.

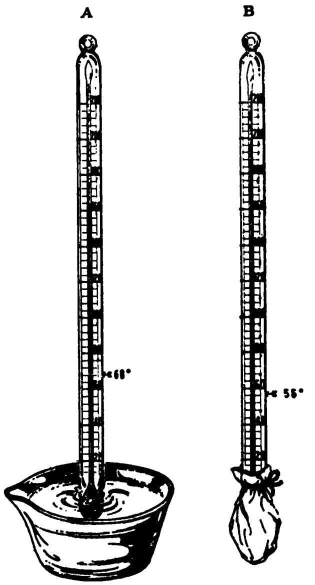


Figure 164. — Experiment to show effect of evaporation on temperature. *A*, thermometer in water (little evaporation); *B*, thermometer with wet rag, which is fanned to hasten evaporation.

In case there is much heat to be removed another thing happens: the *sweat glands* begin to work faster, stimulated by the presence of warm blood around them. Sweat is poured onto the surface of the body, and there evaporates, carrying away much heat. When water evaporates it absorbs heat, as can be seen by either of the following experiments:

Experiments. (1) Take two thermometers. Set one in a vessel of water. Around the bulb of the other tie a cloth wet with water taken from the vessel in which the first thermometer is standing. Now fan the thermometers and note the drop in temperature of the one with the wet cloth (Fig. 164). (2) If the thermometers are not available, tie a dry handkerchief about one hand and a handkerchief wrung out of tepid water about the other. Wave both through the air vigorously. Which feels the colder, and why? Tell why a person feels colder in wet than in dry clothes.

In case of fever, the body becomes hotter than it is when in health, partly because the sweat glands fail to do their duty. The temperature of the body in fever rises above 98.6° Fahrenheit.

How the Heat of the Body is Retained. We have just learned how the body gets rid of excessive heat. In cold weather it is necessary to prevent loss of heat, for too low a temperature is as dangerous to health as too high a temperature.

If you recognize the fact that cold makes the arteries of the skin contract, you will readily understand Nature's way of keeping necessary heat in the body: in just the opposite way from getting rid of it; namely, by driving the blood out of the skin into the body and away from the cold. The less blood brought to the skin, the less heat will escape from it.

Catching Colds. Keeping the blood out of the skin is a safeguard within limits only. You must know that the skin may hold much blood. This is driven out of the skin by cold. When the body is cold for some time, causing great loss of heat, the germs of cold or grip present may get a foothold in the body, causing disease. Without the germs one cannot catch cold. Travelers in the icy North do not have colds, since there are no sick persons to scatter germs. On the other hand, even if germs are present, they are not likely to gain entrance into the blood unless the body is exposed to the cold. Thus, for example, it is dangerous for a person to sit in a cold room below 65° Fahrenheit or to wear wet clothing or too little clothing. Wet shoes and stockings are especial sources of danger. Cold fresh air is wholesome, however, when one is warmly clad.

Alcohol and Body Heat. Alcohol is a drug that has the power of dilating the arteries of the skin, causing a rushing of blood to the skin, as indicated by the red face of the drinker. This makes a person feel warm for a while, but it does not make him warm. It really makes him cool, for the presence of so much blood so near the surface of the body results in a rapid loss of heat. To take a drink of whisky before venturing out into the cold is one of the worst things a person can do. Arctic explorers found out from experience long ago that alcohol is a great hindrance to feats of daring and endurance in the polar regions. But it need not be supposed that alcohol is a good thing in hot climates. It is a well-known fact that the death rate of those who use alcohol is even greater in the tropics than in our own temperate climate.

Shelter. Food and oxygen to make us warm, and well-trained blood vessels in the skin, to regulate the heat, are not sufficient for man: he needs also clothing and shelter. Man's life is largely spent in getting food, clothing, and shelter.

The rooms of our houses should not only be well ventilated, but should also be kept at the right temperature, 68–72° Fahrenheit. If a school room is heated and ventilated correctly, all parts of the room will be comfortable; none will be too hot or too cold, as in the case of many schools in Texas as well as elsewhere. A room should also have moisture enough, for if the air is too dry, the nose and throat will become parched and irritated. The moisture can be supplied by placing a pan of water on the stove. The effects of sitting in a room that is too cold have been explained. If the room is too warm, the blood vessels of the skin become dilated, and on going into the cold air the body loses too much heat from the rich supply of blood in the skin.

SUMMARY

The body is kept warm by the oxidation of the food and tissues. Fats are the best fuel food and are relished in cold weather. Alcohol is doubly harmful in the cold. The body must be kept at a nearly constant temperature not exceeding

98.6° Fahrenheit. The quantity of heat given off from the body is greater when the quantity of blood in the skin is greater, as during exercise or after drinking alcohol. Evaporation of sweat from the body is the most important means of removing the excessive heat from the body during exercise or in warm weather. In cold weather the skin has less blood, and less heat is consequently lost. When one's body loses too much heat for a long period, one is likely to become sick with colds, grip, etc. It is important that our rooms be heated to the right temperature for health and comfort, and that the air in them should not be too dry.

QUESTIONS

1. What are the functions of the skin? 2. How is body heat produced? 3. What becomes of the heat produced in a working muscle? 4. What is the effect of heat on the arteries of the skin? Of cold? 5. Is much or little heat lost when there is much blood in the skin? Why? 6. Why is the skin red when we are exercising? 7. Why is the skin pale when we are cold? 8. Why does a person actually cool off faster after drinking alcohol? 9. What are the harmful effects of prolonged chilling of the skin? 10. Why is too warm a room harmful to a person? 11. Why should the air in a room have a certain degree of moisture?

CHAPTER XLI. HINTS ON CLOTHING AND BATHING

What animals do you see abroad in the winter time? Frogs? Snakes? Insects? You see only birds, covered with feathers; mammals, covered with hair; and man, who uses clothing to retain the heat of the body. In warm weather clothing serves also to protect the body from injury and from the heat and light of the sun.

Kinds of Clothing. Clothing owes its power to retain heat to the fact that heat will not readily pass through dry air. Find out how an ice box (used to keep heat out) or a fireless cooker (used to keep heat in) is made, and you will learn how clothing keeps one warm. Furs hold more air than hair. When a horse or a cow gets wet in winter it suffers much from the cold, for in that case water takes the place of air in the fur. Fur is the best material for clothing to keep one warm in extremely cold climates. Of wool, silk, cotton, and linen cloth, wool is the best for winter and linen for summer wear, for wool holds the most, and linen the least, air in the meshes of the fibers. Clothing should not fit too tightly, for in that case the circulation of the blood is hindered and the heat of the body cannot be well distributed.

Clothing for the Climate of Texas. In Texas "northers" often sweep down, causing a sudden drop in temperature. When it becomes suddenly colder, we should change clothing to suit the change in the weather. Many persons change to woolen or other kinds of heavy underwear in the fall and wear this all the winter, regardless of the weather. This is not the best plan to follow. It is best to have at least three weights of underwear for use at different times. If one has on heavy underwear and the weather suddenly becomes colder, he can increase the underwear by using a light-weight underneath a layer of heavy underwear. Some persons find that they catch cold in changing to light underwear in the spring, but this is usually due to too great difference in the thickness of the underwear. A good rule to follow in changing from winter to summer underwear is to have a medium weight of winter underwear, or two thicknesses of summer underwear, so as to make the change more gradually. These, and many other rules of health that stand the test today, were well known to Benjamin Franklin, who was a keen observer as well as a great statesman.

Our long, hot summers can be made more pleasant for us if we wear light, washable outer clothing. Suits of duck, cottonade, mohair, and the like are light and cool, and in summer they enable us to endure the warmth of the climate better. It is to be noted also that light-colored clothing is, in the sunshine, cooler than dark-colored clothing of the same material.

Need of Bathing. In the study of the skin we learned that various secretions are poured upon its surface by the sweat glands and the oil glands. We also learned that disease germs are likely to be present in the dust and dirt that gather on the skin. From these facts it is apparent that frequent bathing is necessary for cleanliness.

Figure 165. — A soap-book, containing sheets of soap. Avoid the common box of soap at public places.

Washing the Hands. To prevent disease it is especially important that the fingers be washed thoroughly with soap, and rinsed off with clean water, as often as the hands are soiled. The fingers become soiled in many ways, especially by touching such things as door knobs that are handled a great deal. The fingers and hands should be washed well with soap before each meal. It is wise to keep the fingers from touching articles of food as much as possible. The hands should always be washed after touching the body or clothing of any one who is sick and after each visit to the toilet. Avoid using the common towel at public places; use the paper towel wherever it is supplied (Fig. 165).

The Shower Bath. Up to this time most households have been supplied with bathtubs instead of shower baths. This has been due to the fact that the advantages of the shower bath have not been realized, and also to the fact that home makers have not known a practical way to install a shower bath in an ordinary room with a pine floor. Figure 166 shows a simple and cheap shower bath that can be substituted for a bathtub in an ordinary bathroom. Under the shower is a porcelain basin, into which the water runs after trickling off the bather. A curtain is provided to keep the water from splashing on the wall or floor. This shower bath is more sanitary than the tub bath.

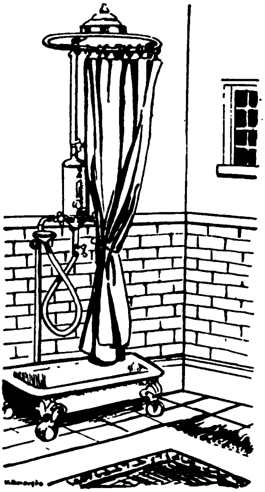


Figure 166. — A shower bath is the most sanitary because the water runs off of the body and away.

Hot and Cold Baths. Since people go to extremes on the subject of bathing, a word of caution is necessary concerning the temperature of the water used. It may be said that water about the temperature of the body or slightly warmer is always a safe temperature. Water much warmer than this should not be used except for some special reason and under the advice of a physician. The water may be cooler, or even quite cold, so long as it leaves a pleasant after-effect on the bather. This applies to those who are well and strong. No one who is at all sick should take cold baths except under the direction of a physician. It is not unusual for persons to be found dead in a bathtub. This shows that a person in delicate health should use some judgment in the matter of bathing. It is never well to bathe immediately after a meal.

Swimming. Swimming is an excellent way to combine recreation and exercise with bathing. It is better than bathing in a tub or a shower bath, as it brings a person out into the open air and gives opportunity for pleasant and healthful exercise. A plunge into the water of a lake, river, or the ocean is very invigorating.

Hot Applications. The curative value of hot applications should be learned. When a person sprains an ankle or a wrist, an inflammation begins there and the part becomes hot and red. This is caused by the flow of blood to the part to effect a cure. In case of sprains, therefore, we can hasten the cure by increasing the flow of blood to the injured part. This is done by the application of hot cloths.

Ventilation of the Bathroom. Bathrooms should be ventilated. When gas is used to heat the water, great care should be taken to prevent suffocation from escaping gas. The heaters should have a hood and flue to carry off to the outside the carbon dioxid and other poisonous products of burning gas.

SUMMARY

Clothing serves to prevent loss of heat. Excessive loss of heat is prevented by the use of extra clothing when out-of-doors and by keeping the living rooms comfortable when indoors. One should wear clothing to suit the climate and the weather. Bathing is necessary for cleanliness. Excessively hot or cold baths should be indulged in with judgment and only in case the after-effects prove to be agreeable.

QUESTIONS

1. Mention some helpful points with regard to clothing for winter in Texas. For summer. 2. Why must the hands be washed very often? 3. Why is bathing necessary? 4. What should be the temperature of the bath water? 5. When should a person not take a bath? Why? 6. Why is a shower bath more hygienic than a tub bath? 7. How would you treat a sprain?

CHAPTER XLII. LOCOMOTION: BONES AND JOINTS

Review. We have learned that different tissues or collections of cells have different duties to perform. Thus glands, mucous membrane, and epidermis are made largely

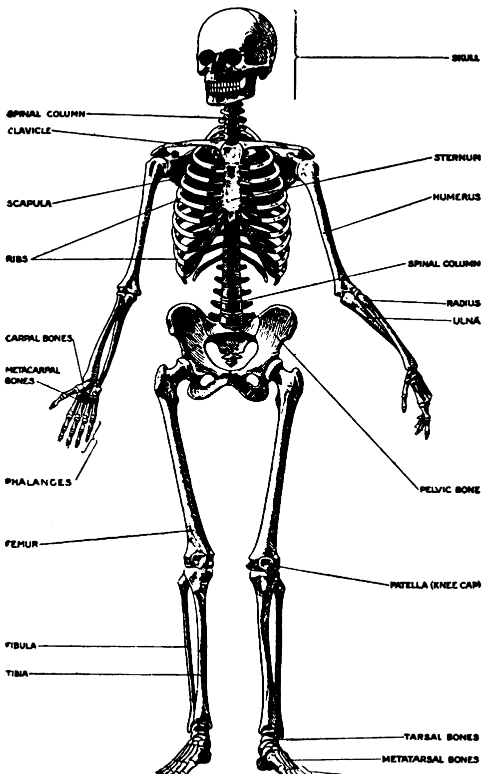


Figure 167. — The human skeleton.

of epithelial tissue. A muscle is made of muscle fibers bound together by connective tissue. The muscle fibers can shorten or contract. Wherever in the body a strong, flexible cord or flap is needed, it is made of connective tissue. Thus the valves of the heart and of the veins are made largely of connective tissue. Muscles are attached to bones by strands of connective tissue called tendons, and bones are bound to each other by similar strands called ligaments. Connective tissue is thus an important supporting tissue of the body.

Cartilage tissue (or gristle) is a supporting tissue used for the framework of the trachea, windpipe, and bronchi, the outer ear, and the nose (Fig. 124). Many bones have at their ends caps made of cartilage, for these caps must be smooth, so as to glide upon each other with little friction, and tough, so as not to break when struck together. Cartilage performs an important duty as packing between the vertebræ of the backbone; for, being elastic, it helps to deaden jars that might otherwise injure the brain.

Observation Work. (1) Secure from a butcher the end of a muscle with the tendon still attached to the bone. Study all that can be made out from the specimen. Ligaments are best studied when studying the joints. (2) Measure your height accurately at bedtime; again on rising the following morning. What do the results prove about the cartilage between the vertebræ of the backbone?

Uses of Bones. With cartilage and connective tissue alone, however, the body would lack the support and rigidity required. This support to the body is furnished by bones of many shapes and sizes, all joined and built up into a system called the *skeleton* (Fig. 167). The skeleton is the framework of the body. With muscles fastened to this, and all covered by the skin, the shape of the body is completed.

The Use of Bones for Support. Bones act as means of support in two special ways. First, they form bony boxes for the protection of the vital organs of the body. The skull is such a box, with its flat bones fitting tightly together

(Fig. 124). The spinal cord lies in a tube (the vertebral canal) made by the hole running through the vertebræ (Fig. 168). The patella, or knee-cap, protects the delicate knee joint from injury. The heart and lungs are situated in the chest and are protected by the shoulder blades, the breastbone, and the ribs. The bones forming these protecting boxes are mainly flat bones containing red marrow, as you can see by studying the sawed end of a rib, which may be secured from the butcher. This red marrow is of special interest because most of the red blood corpuscles are manufactured in it. There are, however, many flat or irregular bones with red marrow that serve other purposes than protection alone; for example, the shoulder blades and the hip bones.

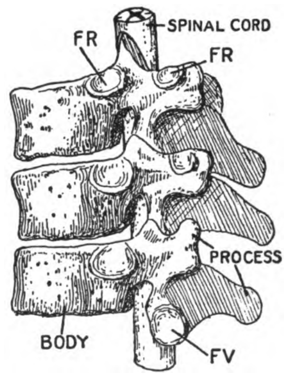
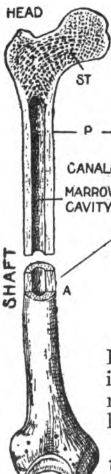
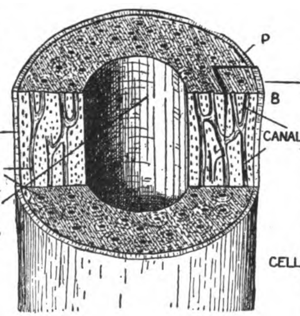


Figure 168. — Three vertebræ with portion of spinal cord in place. *FR*, hollows for attachment of ribs; *FV* surface for attachment of next lower vertebra.

The Use of Bones for Motion. Besides serving as support to the body, bones are used as attachment for the powerful muscles that move the body. Many flat bones are movable to some extent, the lower jaw and the shoulder blade serving as good examples. The bones of the hand and the wrist are short and irregular bones, with red marrow, and are of course movable. But for rapid and powerful motion there are certain long bones of the limbs with their muscles to move them. These bones are light and of sufficient thickness to do their work. The femur or thigh bone is an example of such a long bone. It is enlarged at both ends, where it joins other bones, and has projections to which muscles are attached by their tendons. Inside, the enlarged end of the bone has a spongy appearance; that is, it is full of hollows scattered among the bone tissue (*ST*, Fig. 169). The hollow between the spongy ends is filled with fatty marrow.

Bone Tissue. In a cross section of a long bone, such as appears in the center of a piece of round steak, the bone tissue seems perfectly solid and impenetrable. Under the microscope, however, it has quite a different appearance.





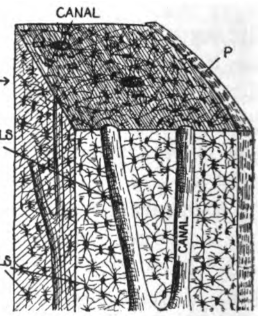


Figure 169. — Femur, one half in longitudinal section, showing spongy tissue (*ST*) in end and compact tissue around the marrow cavity in shaft. *P*, periosteum. Cut end, *A*, enlarged in Figure 170.

Figure 170. — End *A* of Figure 169 enlarged, showing bone tissue in shaft of femur.

Figure 171. — Bone tissue (block *B* of Figure 170) still more enlarged. This shows the arrangement of bone cells (black dots) about the canals. Still finer canals run out from the cells.

The apparently solid part of the bone is seen to be traversed by fine canals containing blood vessels and nerves, and about these canals living bone cells are arranged, as shown in Figures 170 and 171. The cells themselves are connected with the canals and with one another by still finer tubes. Thus it is seen that even the solid part of bone is porous and supplied with blood, which carries food and oxygen to the bone cells, as it does to other parts of the body. Figures 169–171 should be carefully studied to make this point clear.

All bones are surrounded by the *periosteum* (*P*), which holds many blood vessels and nerves that pass through it on their way into the bone.

EXPERIMENTS TO SHOW THE COMPOSITION OF BONES. (1) Examine a bone that has been burned thoroughly. Compare it with pieces of limestone. It is the mineral part of the bone, made up largely of limestone and phosphate of lime. It is the part that makes bone hard. (2) Soak a bone of convenient size, say a chicken drumstick, in strong vinegar or weak hydrochloric acid, and note the result. Tie the bone into a knot (Fig. 172). State what has been removed from the bone. What is left is animal matter, which gives toughness and a certain amount of elasticity or springiness to the bones.

Figure 172.—Bone tied into a knot.

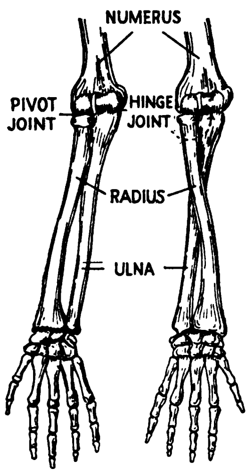


Figure 173. — Diagrams, showing how the hand may be turned around by means of the pivot joint of the radius. (For use of hinge joint see Figure 182.)

Joints. The place where two bones are joined together is called a *joint*. Some joints, as those of the skull bones, are *immovable*. The bones of the wrist and ankle glide over one another; their joints are therefore called *gliding joints*. The elbow and the knee joints allow a greater freedom of motion to the arms and legs, which move like a hinged door; they are called *hinge joints* (Fig. 173).

The upper arm is attached to the shoulder blade by a *ball-and-socket joint*, allowing the arm to be moved in almost any direction. By a similar joint, but with a deeper socket, the femur or thigh bone is attached to the hip bone. At the elbow there are two joints. Here the ***humerus***, or bone of the upper arm, joins the two bones of the forearm, — the ***radius*** on the thumb side and the ***ulna*** on the side of the little finger. The ulna is attached to the humerus by a hinge joint, the radius by a pivot joint. This arrangement allows the latter bone to twist around

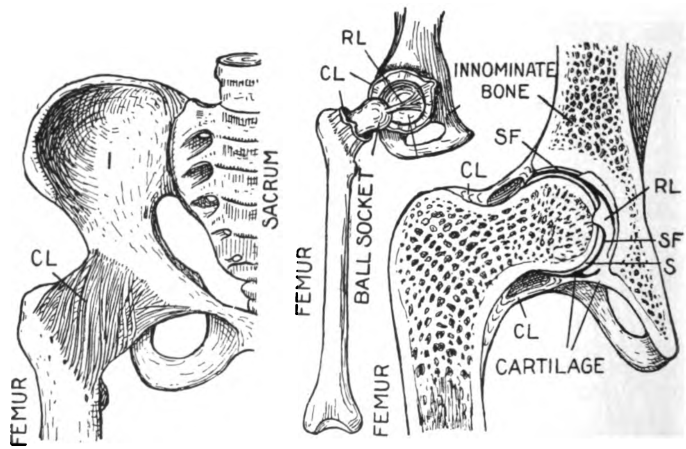


Figure 174. — Hip joint; *I*, innominate bone; *CL*, outer ligament.
Figure 175. — Hip joint with outer ligament (*CL*) cut to show the inner or round ligament (*RL*).
Figure 176. — Section of hip joint. *CL* and *RL*, ligaments; *S*, synovial membrane over cartilage of joint; *SF*, synovial fluid.

and enables us to turn the hand palm up or palm down (Fig. 173), in a way in which we cannot turn the foot. Study other joints in your own body and try to tell what kind of joint each is.

At the joints the bones are fastened together with ligaments or strands of connective tissue, which extend across the joint from one bone to the other. Two kinds of ligaments holding the thigh bone in place can be seen at *RL* and *CL*, Figures 174–176. The ends of the bones form smooth surfaces covered with smooth, tough cartilage. To reduce friction still further a lymphlike fluid, the *synovial fluid*, is present in the joint. Further details of the joint can be studied in these pictures and also in an actual joint of some animal.

OBSERVATION WORK. Secure a ball-and-socket joint from the butcher, first having him saw it in two lengthwise. The hip joint of a pig or calf would answer best. Study the solid and the spongy parts of the bones, the smooth cartilage tip of the ball, and the lining of the socket and the ligaments.

SUMMARY

Bones with connective tissue and cartilage form the framework of the body. Bones also protect delicate organs from injury, and, having muscles attached to them, act as levers to move the body. The two hundred or more bones of the body are of many different shapes, according to the function each performs. The long bones are hollow, so as to combine strength with lightness of weight. The flat bones contain red marrow, where the red blood corpuscles are manufactured. Even the solid part of the bone is porous, being traversed by fine canals containing blood vessels and nerves. The bone cells are arranged around the canals within the bone substance. Bone tissue contains animal matter for toughness and mineral matter for firmness.

Bones are bound together by ligaments at the joints. Smooth cartilage and synovial fluid in the joint prevent friction as the bones rub upon each other.

QUESTIONS

1. Name some organs of which cartilage tissue forms a part. 2. What is a tendon? A ligament? 3. Point out each in two different pictures. 4. Of what kind of tissue are tendons and ligaments chiefly composed? 5. State the uses of bones. 6. In what direction do the canals run through the long bone? 7. What are the

canals for? 8. How are the bone cells arranged with reference to the canals? 9. Give the chief uses of each bone that may easily be seen in Figure 167. 10. Name the kinds of joints and give examples. 11. Name the two joints in the elbow. 12. State the use of each. (Study Figs. 173 and 182.) 13. How are bone cells supplied with blood? 14. How can we prove that bones contain mineral matter? Animal matter?

CHAPTER XLIII. HYGIENE OF THE SKELETON

The skeleton may be injured by strong blows or heavy falls, but it will be shown in this chapter that the bones are more usually misshapen by tight clothing or by habits of keeping the parts of the body in improper position.

Hygiene of Joints. Sometimes a joint becomes dislocated or sprained; when it is dislocated the bones become separated at the joints so that they will not return to their proper place unless pressed back by force. When a finger is dislocated, as sometimes happens when playing base ball, it should be pulled until it goes back into place. When a joint is sprained the ligaments are strained, or they may be torn loose from their attachment to the bone. Hot applications to the sprained spot will help to effect a cure. A severe dislocation or sprain should receive the immediate attention of a physician.

Hygiene of Bones. It is very important to recognize the fact that children's bones contain a small proportion of mineral matter, and are therefore soft and flexible. Since this is true, it is easy to see that children's bones are easily bent out of shape and permanently deformed. A baby may bend his legs out of shape by beginning to learn to walk too early, or by walking too much. Children who are improperly fed do not develop their bones properly.

Proper Position. It is important for old and young, but especially for the young, to stand and sit up straight. The chest should be raised and the shoulders thrown back. This is better not only for the bones, but for the lungs and other organs, and it also improves the personal appearance. Many persons are one-sided from always carrying things, school books for example, on the same side of the body.

Observation Work. Measure carefully the height of each shoulder from the ground. Compare the two measurements to find out whether or not you are one-sided.

Tight Clothing. Tight clothing is very harmful for young and old. The habit of lacing the waist tightly is very common and is most dangerous. The feet, too, are often harmed by wearing tight and ill-fitting shoes. Shoes should fit well and should not have high heels. The foot naturally acts like a spring in deadening the shocks as we walk. This protects the brain and other organs of the body. There are three structures in the skeleton which help to prevent the jarring of the brain: the elastic cartilages between the vertebræ, the curvature of the spinal column, and the arch of the foot (Fig. 179). Of these the springiness of the foot is perhaps the most important. But when French or very high heels are worn, the foot tends to slide down into the toe of the shoe, the foot is pinched still more, and corns and other painful ailments of the feet are caused thereby.

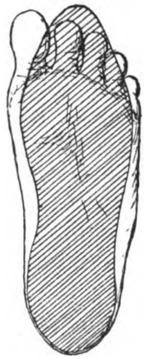


Figure 177. — A deformed foot.
Figure 178. — Natural shape of foot and shape of ill-fitting shoe.

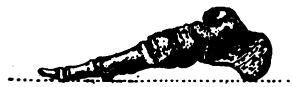


Figure 179. — Bones of foot, to show arched shape.

School Desks. Young people spend a great deal of their time sitting at their desks in school. It is essential to their health that they learn to sit up straight and that they make it a habit to do so. This is, of course, impossible when the desk is too high or the seat too low. If the seat is too low, the position of the pupil is sure to be cramped. If it is too high, the feet dangle in the air, the pressure on the muscles of the thigh cuts off the circulation, and the weight of the feet bends the thigh bone out of shape. If the desk is too high, the arm and shoulders are raised too much when writing; if it is too low, it is necessary to stoop when working over the desk, and round shoulders and hollow chests are the result. The desk should also be at the right distance from the seat, not so close as to press against the chest, nor so far away as to make it necessary to lean forward.

By neglecting to supply proper desks, many school authorities are causing physical defects in children,

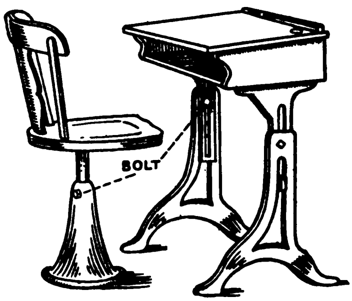


Figure 180. — A school desk and seat adjustable to size of pupil.

defects that often last through life. In case the school does not possess comfortable and hygienic school desks, the teacher can often make a child comfortable with a box as a foot rest or with some other device, or she can relieve the situation for the time, particularly with the youngest children, by giving frequent short recesses and by dismissing early in the afternoon. It is important that desks of right size and shape should be furnished.

SUMMARY

Serious dislocations and sprains should have the prompt attention of a physician. Hot applications are helpful to a sprained joint.

Mineral matter is deposited in bones throughout life. The bones of children are soft and therefore easily bent out of shape.

Correct positions in sitting and standing, and avoidance of tight clothing, are essential to the proper growth of the bones. As children at school must sit at their desks many hours each week, it is important that the desks be of correct size and shape and that the pupils adopt the habit of sitting erect.

QUESTIONS

1. Why may children's bones be easily bent out of shape? 2. How may you develop an erect, strong framework of your body? 3. What can you say as to the fit of shoes? 4. Mention some harmful effects of tight clothing. 5. State the importance of having the right kind and size of school desk.

CHAPTER XLIV. LOCOMOTION: MUSCLES

When a boy is large in stature, his size is due mainly to the size of his bones; when we say he is strong, we refer to the power of his muscles to contract. When a boy

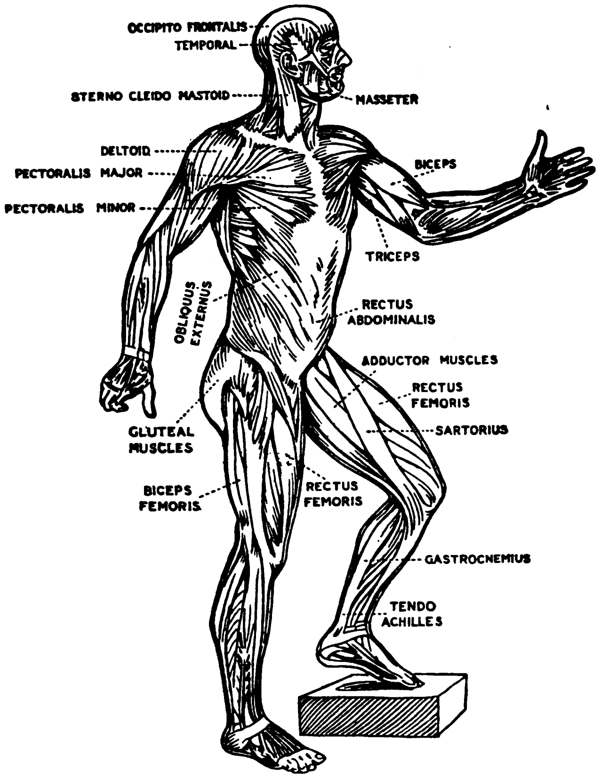


Figure 181. — The muscles.

wishes to show his strength he holds out his arm and says, "Feel my muscle," and is proud to show the size and hardness of the biceps muscle.

Primary Use of Muscles. Throughout this book the chief use of the muscle has been described as producing locomotion. But muscles have other uses in the body than those just described. They are used in swallowing and in performing the movements of the digestive organs, such as peristaltic movements. A large number of muscles are used in breathing. The tongue is a mass of muscles. We noted that the heart is a muscular sac, the work of which is to pump blood, and that the arteries and veins contain muscles. As long as we live there must be more or less continual motion of organs in the body.

The larger motions of the body are performed by strong muscles attached to bones. Each muscle runs across the

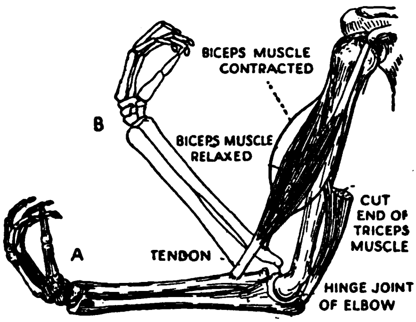


Figure 182. — Muscles are attached to bones for the larger motions of the body.

joint, from one bone to the other; and thus, when the muscle contracts, one bone is moved toward the other. For example, when the biceps muscle (Fig. 182) contracts, the forearm is pulled up at an angle toward the upper arm. In this way the fingers, arms, legs, etc., are moved and the whole body is carried from place to place, as in walking, running, and jumping. Even when standing many muscles are in use (Fig. 183). About two fifths of the weight of the body, or more than one half of the soft parts of the body, consist of muscle (Fig. 181). An inspection of the meat in a butcher's shop will convince one of the quantity of muscle it takes to carry on the work of an animal's body, for all the lean meat sold by the butcher is muscle.

Secondary Uses of Muscles. Muscles serve other purposes than that of producing motion either within the body or for taking the body from place to place. First, they cover the skeleton. Thus, with the skin as a covering for all, muscles complete the shape of the body. To secure a graceful development of the body it is first of all necessary to develop the muscles properly. Second, muscles form the walls of cavities. The cheek, for example, is made of muscles which form the sides of the mouth, and the wall of the abdomen is a muscular structure that protects the intestines.

Figure 183. — The large muscles used in standing.

Two Kinds of Muscles. A little reflection and experiment will show that there are two kinds of muscles. You can move your finger, your eyelids, or your arm at will. But you cannot make your heart beat, nor cause your stomach to begin its movements, and after food has passed into your throat, you cannot stop it from going down the gullet. There must, therefore, be two kinds of muscles: those that are under the control of the will and those that are not. The muscles used in the large movements of the body, as those of the limbs, are under the control of the will and are called *voluntary muscles*. Muscles that are not under the control of the will are called *involuntary muscles*. Mention organs that appear to you likely to contain involuntary muscles.

There is a great difference in the cells of which the two kinds of muscles are made up, as shown in Figure 184. The voluntary muscle cells or fibers are striped crosswise (I); the involuntary muscle cells are smooth or unstriped

(III). The striped muscle fibers have to contract quickly and forcefully; the smooth fibers act slowly. The heart

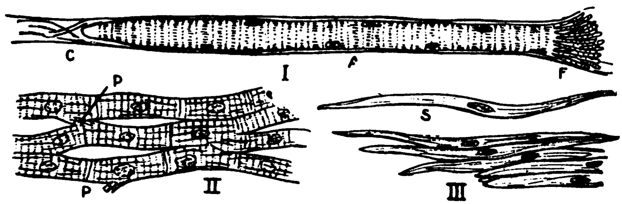
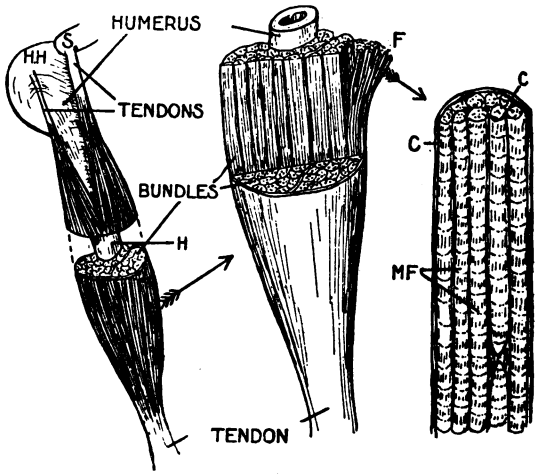


Figure 184.—Muscle fibers: I, striped, voluntary; II, striped of heart; III, smooth. *C*, connective tissue; *F*, cut ends of fibrils; *P*, process of heart muscle fibers; *S*, a single smooth muscle cell.

muscle is therefore an exception, in being involuntary but striped (II), for the contraction of the heart must be rapid like that of the limb muscles.



Figures 185–187.—Structure of a muscle. Figure 185, biceps muscle of arm, with portion cut away exposing the bone (*H*). Figure 186, lower portion of Figure 185 more enlarged, showing the larger bundles; *F*, smaller bundles within larger bundle. Figure 187, a smaller bundle containing muscle fibers (*MF*) bound together by connective tissue (*C*).

Structure of a Muscle. Muscle fibers are connected together into a whole organ, a muscle, with connective tissue fibers, which extend all through the muscle and come out at the ends to form the tendon (Fig. 185). The function of the tendon is to bind the muscles to the bones. Often the bone that is to be moved is some distance from the muscle that moves it. In the hands and feet, for example, the tendons are long and slender.

OBSERVATION WORK. Study your forearm, hand, and fingers for the parts mentioned above. Move your fingers freely and at the same time watch all parts of the arm and hand to determine the relation of muscles, tendons, bones, etc.

SUMMARY

Muscles, by contraction, produce all motion of the body. Some muscles are involuntary and are made up of smooth muscle fibers. Such muscles carry on the movement of the internal organs. The voluntary muscles, made of striped fibers, are attached to bones, and with them as levers, move the limbs.

QUESTIONS

1. What are the uses of muscles? 2. How do the two main kinds of muscles differ? 3. How do the heart muscles differ from these? 4. How are muscles fastened to bones? 5. Place your biceps muscle in position *B*, Figure 182; what joint does the lower tendon of the biceps cross?

CHAPTER XLV. HYGIENE OF THE MUSCLES

Review. State in your own words whence the muscles derive the energy with which to do work.

Food must be brought to the muscles to repair them as they are wasted by use and to furnish them with energy. Blood vessels course through the muscles, and the blood capillaries come close to the muscle fibers or cells as they do to all the cells of the body (Fig. 188). This is, of course, what you would expect from what you have already learned about the relation of the capillaries to the cells. To nourish the muscles properly, good and properly varied food must be eaten. An athlete training for a contest is very careful about his diet, selecting the wholesome foods and avoiding greasy foods and pastry.

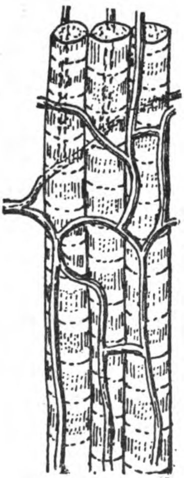


Figure 188. — Blood capillaries supplying muscle fibers.

Alcohol and Tobacco. Alcohol and tobacco are strictly avoided by athletes, as they have uniformly found that these drugs reduce their strength. If a boy will abstain from alcohol and tobacco in order to win a foot-race or help win a football game, does it not pay to avoid these drugs in order to have a healthy body for the battle of life? Some persons believe that they can do harder work under the stimulus of alcohol; but they are mistaken in this, for experiment after experiment has proved that alcohol actually lessens the power of the muscles to contract. This is another fact which Benjamin Franklin knew from observation, and it has been later proved by scientific experiment over and over again.

Fresh Air. An ample supply of fresh air is another essential to the health of the muscles, as it is to the health of the whole body.

Exercise. Another thing that is absolutely essential to the health of the muscles is exercise. Its most important advantage is the effect on the circulation of the blood and lymph, as described in Chapter XXXVII. By exercise the heart is made to beat faster, and is thus itself exercised; the breathing movements are increased; the veins are squeezed with each contraction of a muscle, and the blood is forced on toward the heart. All these activities help

Figure 189. — A healthful form of recreation.

the circulation of the blood and the lymph. Exercise also makes the muscles harder and stronger.

Play. To be of the greatest value to the body, exercise must be pleasant. Play is, therefore, an essential element in one's training. All young animals play; it is nature's way of developing their muscles. Children should be allowed their right to a reasonable amount of play. Games, moreover, develop the social instinct, teach children to work together (team work), to be honest, to be considerate of one another, to stand up for one's rights, and to understand human nature. Older persons should engage in out door sports as circumstances will allow. Name ten good games that require some exercise out of doors.

Gymnastics. Gymnastic exercises are valuable principally because by means of them deformities may be corrected or undeveloped muscles brought out. Exercises for almost every voluntary muscle of the body have been invented, so that a person may take a scientific course in physical culture by the gymnastic method. Gymnastic exercises are of great importance in the bodily development of boys and girls in crowded cities, where there are fewer opportunities for other forms of exercise. But gymnastic exercises usually lack interest and are, in general, not so good for the health as enjoyable games. A five or ten minute drill with movement of the trunk and limbs may, however, be very beneficial in school, where the pupils have to sit still a long time. A brisk walk into the open air for five minutes, however, is better.

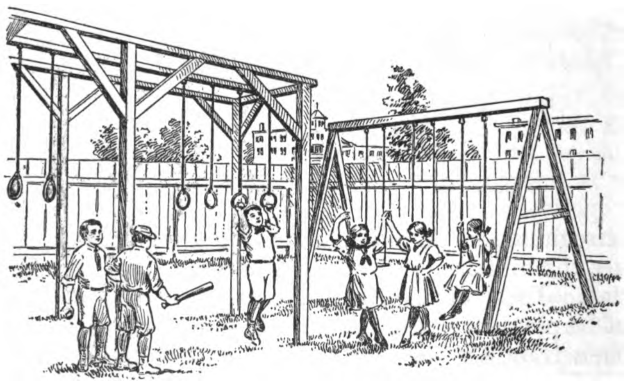


Figure 190. — A playground is a valuable part of a school equipment.

Work. Boys need a great deal of play, but also an equal amount of good hard work. A good combination for boys would be splitting wood, digging bait, and going fishing. Some hard work is good for girls too, for example, sweeping (but not by the dry method) and washing dishes; but, girls also need an equal amount of play.

Fatigue. There is a limit to the exercise one ought to take. Have you ever been on a picnic or a day's tramp and come home very tired? And did you not feel sore the next day, the very muscles hurting when you touched them? Why did they hurt you? Study Figure 113 and try to tell the reason. Waste products from the muscle cells themselves accumulate during continued heavy exercise faster than they can be carried off by the blood, and they then act as a toxin on the cells of the body. This condition is called *fatigue*.

Rest. Rest, therefore, is a necessity. Rest gives the muscle and nerve cells a chance to get rid of waste substances and to rebuild worn-out protoplasm. During rest the building-up process is greater than that of the tearing-down. A person who does not rest sufficiently cannot do his best work, does not enjoy life fully, and may finally become a prey to disease germs.

SUMMARY

Blood capillaries supply all the muscle fibers with food and oxygen and carry away waste products produced by exercise. They also carry alcohol and the poisons of tobacco to the fibers, weakening the muscles.

Exercise, if pleasant and enjoyable, is highly beneficial to the muscles. Outdoor games are the best form of exercise, except for special purposes. We should never exercise to the point of being dead tired, but should stop and rest when the point of pleasant fatigue is reached.

QUESTIONS

1. How do the muscle cells secure their nourishment (Fig. 188)? 2. How can the poison in tobacco reach the muscle cells? 3. What part of Figure 186 is the bundle shown enlarged in Figure 187? 4. What are some of the needs of muscle cells (Fig. 113)? 5. What drugs weaken the muscles? 6. Discuss the value of exercise to the muscle. 7. What is the chief value of play? 8. Discuss the use of gymnastics. 9. Why is rest necessary? 10. How is fatigue produced?

CHAPTER XLVI. THE NERVOUS SYSTEM: GENERAL

Thus far we have considered the body as being made up of myriads of separate cells, each with its own work to perform. These cells multiply and unite to form tissue, and tissues are united to make up organs. We have considered the different organs chiefly as separate parts of the body, without especially noticing how one part acts upon another. We have studied the *operation* or work of the cells, tissues, and organs. In this chapter we shall see how the parts of the body *coöperate* or work together.

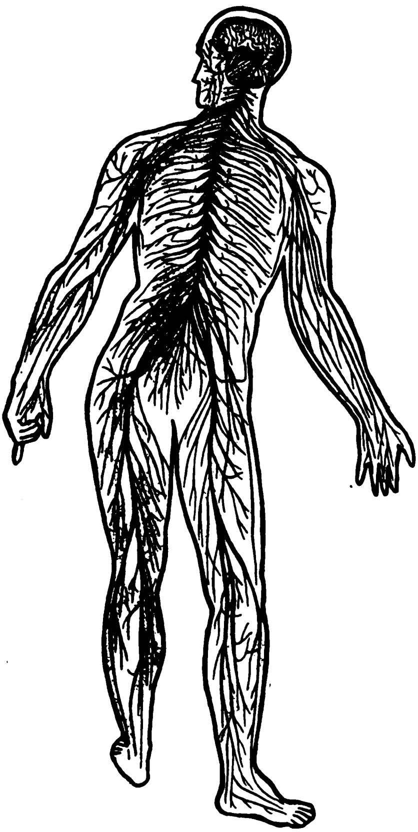


Figure 191. — The nervous system.

Examples of Coöperation. Every one is familiar with examples of the coöperation of the organs for the good of the whole body. The blood serves every cell in a very important way, as has often been pointed out in previous chapters. The stomach and intestines digest food, not for themselves alone, but for the whole body. Even the presence of small quantities of waste substances is useful to the body, because they cause fatigue and induce sleep. When we consider the body as made up of many coöperating parts, we may liken it to a perfect baseball team, each one of whose members does the right thing at the right moment, all working together so that the team may win.

Review Work. Make a list of the most important organs you have studied and state what each does for the good of the whole body.

The more you think about it the more you will realize how perfectly this machine, the body, works. If some one strikes at you, you wink your eyes, throw up your hands, and perhaps step back. If a particle of food goes the wrong way on passing down the throat (Fig. 121), you cough; or if dust enters the nose, you sneeze. As you taste food and begin to chew, the digestive glands begin to secrete.

If you prick your finger with a pin a message is sent to the brain and spinal cord, and in an instant a message is sent back to the proper muscle to remove the finger from the place of danger. Or I may say, "Move your right thumb"; you hear what I say and do as I request. My voice, your ear, and your thumb have perfect means of communication between themselves.

Review Work. Tell at least a half-dozen things that happen in as many of the organs of the body when you begin to exercise, — for instance, to run. Review Chapter XL and explain how heat and cold affect the blood vessels of the skin.

Nerve Cells. We have already learned how communication between all the cells of the body is brought about by the blood. We shall now learn of another system of communication; namely, the *nervous system*. The nervous system is made up of cells, as is every other part of the body. A little reflection would lead us to suppose that nerve cells are longer and more slender than any other cells, even than muscle and connective tissue fibers, and this is true.

Figure 192 is a diagram of a nerve cell. The body of the cell (called simply *nerve cell* for the sake of brevity) contains the nucleus, and has running off from it one or more long projections or processes and usually many short ones. The short processes are of use in communicating with adjoining cells; the long ones, the *nerve fibers*, run to the various cells of the body or to other nerve cells. The nerve fibers may be very long; for example, those running into the feet from the small of the back are a yard or more in length. A single nerve fiber cannot be seen by the naked eye, but when many are bundled together they form a *nerve*, and a nerve can be seen as a white strand of greater or less thickness running through the flesh.

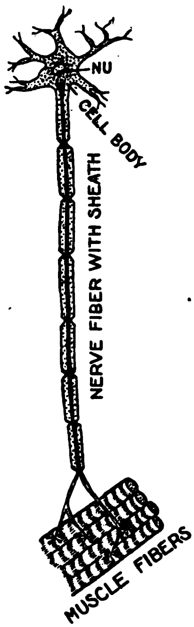


Figure 192. — A nerve cell.

The Function of Nerves. If you were asked what the brain is for, you would probably say, "To know and feel with," by which you would mean that the brain is the organ of the mind. If asked the function of nerves, you would now readily answer that nerves carry messages or impulses from one part of the body to another, and so keep the parts coöperating for the good of the whole. These two answers are as nearly correct as most people can state them.

We might compare our system of nerves with a telephone system. The nerves correspond to the wires which connect homes, stores, and offices in a city. There are, also, nerve centers, and the brain and the spinal cord correspond to the central office or exchange of the telephone system.

When you wish to telephone, you first call central and give the number you want. Likewise, when you touch the point of a pin with your finger, a call is sent to the central of the body. Again, the central operator of the telephone gives you the number you call for and rings that number. So, too, in the brain or in the spinal cord, the message, "Sharp object at finger," is changed to "Move finger away," and this message is sent to the proper muscles of the arm and hand. There are, therefore, nerves running *in* from the skin, which bring us in touch with the outside; and there are nerves running *out* to the muscles, controlling their action.

The organs of the nervous system might be said to consist of the *central nervous system*, the brain and the spinal cord, containing most of the nerve cells; and the *peripheral nervous system*, consisting of nerves and containing mainly nerve fibers that carry messages to and from the central nervous system and the other parts of the body.

SUMMARY

The functions of the nervous system are to act as the organ of the mind and to control all the organs of the body. The nerve cells receive or send on impulses or messages, and their nerve fibers carry the impulses from one part of the body to another.

QUESTIONS

1. Do you think the various parts of the body are independent of one another? 2. Give reasons for your answer. 3. Give examples of coöperation of organs. 4. How are parts brought into communication? 5. Wherein is the nervous system like a telephone system? 6. Name the parts of the central nervous system. 7. Of what does the peripheral nervous system consist? 8. Find these parts on Figure 191.

CHAPTER XLVII. THE BRAIN

Since the brain plays such an important part in the body, it is often pointed to as the most important organ of the nervous system. We must bear in mind, however, that all parts of the nervous system are of importance. The organs of the nervous system are:

1. The brain (Fig. 199).
2. Twelve pairs of nerves arising from the brain and running out mainly to the head and shoulders and to the heart, stomach, and other important organs of the thorax and abdomen.

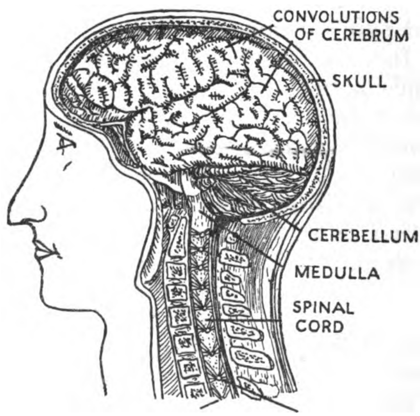


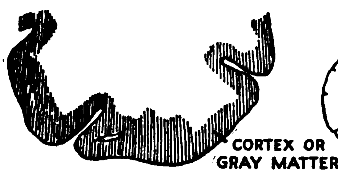
Figure 193. — The brain and upper part of the spinal cord.

3. The spinal cord (Fig. 199).
4. Thirty-one pairs of nerves arising from the spinal cord and sending out branches into the trunk and the limbs (Fig. 200).
5. The sympathetic ganglia and their nerves (Fig. 199).

1 and 3 make up the central nervous system; 2 and 4, the peripheral nervous system.

The Brain. The brain lies in the hollow of the skull, and the spinal cord lies in the canal running through the spinal column (Figs. 72 and 193). Besides the bony covering, both have three double protective coverings.[1] All hollow spaces between the coverings are filled with a kind of lymph. The coverings and the lymph cause the brain and the cord to fit snugly into their cavities. The brain is also protected from jars by the springy arch of the foot, by the curves of the backbone, and by the cushions of cartilage between the vertebræ.

Ganglia. The nerve cells are all contained in certain definite parts of the brain and spinal cord and in certain



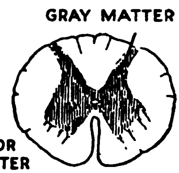


Figure 194. — Section of portion of the brain; gray matter near the surface.
Figure 195. — Section of spinal cord; gray matter on the inside.

small collections of nerve cells called *ganglia*. A ganglion is simply a collection of nerve cells. In this sense the brain and spinal cord may be considered enormous ganglia. Figure 203 shows a number of ganglia. One region of the brain and of the spinal cord is, then, composed mainly of nerve cells, and this is called *gray matter* because of its color. The region of fibers is white and is called *white matter*. In the brain the gray matter is on the outer surface and forms the *cortex* of the brain (Fig. 194); in the spinal cord the gray matter is on the inside (Fig. 195).

The brain consists of three main parts: the cerebrum, the cerebellum, and the medulla.[2]

[1] The three together are called the *meninges* (M, Fig. 209). The disease of the nervous system called cerebrospinal meningitis derives its name from these membranes, which are inflamed by the disease.

[2] The medulla is also called the "bulb."

The Cerebrum. Cerebrum is the Latin word for brain. The cerebrum consists of two halves, the *cerebral hemispheres* (Fig. 196), connected by a mass of fibers. In a man it is the largest organ of the nervous system, though this is not the case in some of the lower animals; the more intelligent animals have a large cerebrum. The larger the organ is, the more nerve cells it may contain, since the larger size increases the extent of the cortex or gray matter. In man and in several of the more intelligent animals, as the dog and the horse, the extent of the surface of the cortex is further increased by folds or *convolutions* (Figs. 193 and 196).

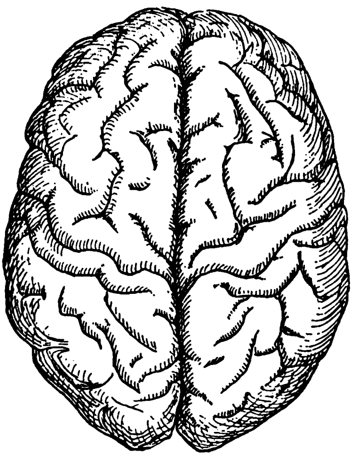


Figure 196. — The brain from above; only the cerebrum is seen in this view. (Compare Figure 198.)

A great number of fibers connect the different parts of each hemisphere of the cerebrum (Fig. 197), connect the hemispheres with each other, and run out from the cells to the spinal cord and to various parts of the body. These fibers passing from the cerebrum into the spinal cord *cross* in the medulla; if the left side of the brain were injured, the right side of the body (except the head) would be paralyzed.

Functions of the Cerebrum. The cerebrum is the organ of the mind. Without it we could not know, think, imagine, remember, or do anything which we commonly associate with the activities of the mind. The cerebrum receives impulses from sense organs (ear, eye, nose, tongue, and skin) by means of fibers starting in the sense organs and ending in cells in the cerebrum. The cerebrum thus receives sensations. Without the cells of the cerebrum we would have no sensations of hearing, sight, smell, taste, or touch, nor would we feel hungry, tired, cold, or warm. In the cerebrum are other cells, from which fibers run to the voluntary muscles. These cells send impulses to the muscles that cause them to contract. Without these cells we could not cause our muscles to obey our will.

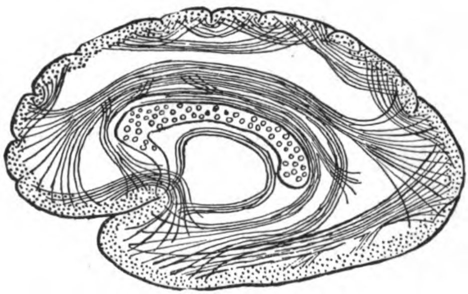


Figure 197. — Nerve fibers connect the parts of the cerebral cortex with one another.

The Cerebellum. *Cerebellum* means little brain. It lies behind the medulla and below the dorsal part of the cerebrum. The cerebrum is so large in man that it covers the cerebellum, which cannot be seen from above (Fig. 196). A frog whose cerebellum has been injured cannot sit up; or, if it falls into the water, it makes an effort to swim, but with irregular and ill-controlled movements. A man whose cerebellum has been injured staggers in his walk as though intoxicated. One function of the cerebellum, therefore, is to keep the muscles ready for action and to make the muscles used in walking, standing, and running act together in an orderly manner, or, in other words, to coördinate their action. It probably has other functions not yet understood.

The Medulla. With both the cerebrum and the cerebellum injured, an animal still lives. If this animal is a pigeon, for example, grains of corn placed on the ground beside it will awaken no response, for without the cerebrum the animal cannot see, nor can it will to act; and without the cerebellum it cannot even maintain an upright posture. However, if a grain of corn is placed in the pigeon's mouth, the muscles that are used in swallowing will act and the grain of corn will pass down the throat. As the grain touches the mouth, it starts impulses that pass along nerves leading to cells in the *medulla*. The word medulla means pith. From the medulla, fibers then carry impulses back to muscles engaged in swallowing. Such action is called *reflex action*, and will be more thoroughly explained below.

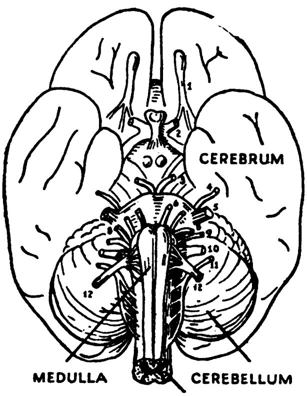


Figure 198. — The brain from below; 1 to 12, cranial nerves.

If the animal has lost the entire brain, including the medulla, the heart stops beating, the breathing movements cease, and death occurs. This proves that these vital movements are under the control of the medulla, which is therefore sometimes called the vital knot. All the fibers connecting the higher parts of the brain with the spinal cord and the various parts of the body pass through the medulla.

SUMMARY

The brain contains millions of nerve cells in the cortex, or gray matter, and has many fibers running in and out. The brain consists of the cerebrum, the cerebellum, and the medulla. The cerebrum performs the functions of the mind, as the will, reason, memory, etc. The cerebrum of man is larger than that of any of the lower animals. The cerebellum serves chiefly to coördinate the movements of the muscles. The medulla controls the breathing movements, the heart-beat, and other vital processes. It is the center of reflex action for parts of the body and also contains nerve fibers leading from the brain into the spinal cord.

QUESTIONS

1. Name the parts of the nervous system. 2. How many pairs of nerves run out from the central nervous system? 3. What are these together called? 4. What do the flaps at *M*, Figure 200, represent? 5. What is a ganglion? Point out ganglia in at least one picture. 6. What are the functions of the cerebrum? 7. How would a person with an injured cerebellum act? 8. What is the work of the medulla? 9. What fibers pass through the medulla?

CHAPTER XLVIII. THE SPINAL CORD AND SYMPATHETIC SYSTEM

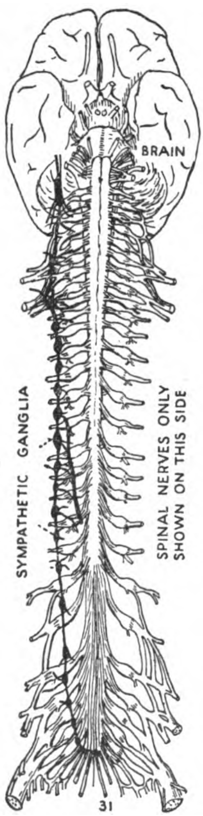


Figure 199. — The brain; the spinal cord with beginnings of its nerves; the sympathetic nerve ganglia of the right side.

From a study of the functions of the brain, as described in the preceding chapter, one might conclude that it controls all the actions of the organs. The different parts of the brain have, indeed, a variety of duties. But we shall learn in this chapter that the spinal cord has important duties of its own, and that the sympathetic system plays an important part in the control of certain organs.

Description of the Spinal Cord. The brain ends and the spinal cord begins at the place where the cranial cavity (Fig. 72) communicates with the vertebral canal. An inspection of Figure 199 discloses the fact that the spinal cord is a continuation downward of the medulla. The cord is about eighteen inches in length. Like the brain, it is covered by the *meninges* (*M*, Fig. 200). It is further protected by a bony covering, the vertebræ of the spinal column, shown in Figure 168.

The *gray matter* of the spinal cord, containing the nerve cells, is on the inside. The shape and position of the gray matter can best be understood by a study of Figure 200. A cross section of the gray matter (*G*, Fig. 200) resembles the letter *H*. The four points of the letter represent the four ridges (*R*) of the gray matter. In Figure 200 the white matter (*W*) has been cut away, exposing a portion of the two dorsal ridges (*R*) of the gray matter.

The Spinal Nerves. There are thirty-one pairs of nerves, called the *spinal nerves*, that start off from the spinal cord to supply the trunk and the limbs with nerve fibers. (Study Figure 199.) The spinal nerves leave the cavity of the backbone through openings between the vertebræ, as can be seen in Figure 168.

Each spinal nerve is attached to the spinal cord by two roots, one on the dorsal side (the *dorsal root*) and one on

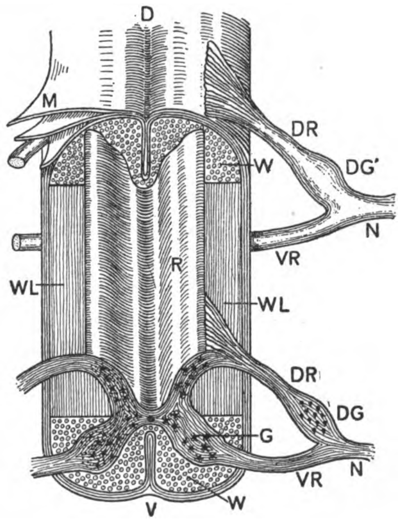


Figure 200. — Spinal cord; cut end with portion of white matter (*W*) cut away, exposing the dorsal ridges (*R*) of gray matter. *D*, dorsal; *V*, ventral; *WL*, nerve fibers of white matter cut lengthwise; *G*, cross section of gray matter; *M*, meninges or covering membranes; *N*, spinal nerve; *DR*, *VR*, dorsal and ventral roots; *DG*, dorsal or sensory ganglia.

the ventral side (the *ventral root*). The nerve fibers running out through the ventral root begin in the cells of the ventral ridge of the gray matter. The nerve fibers coming in through the dorsal root come from a special ganglion of nerve cells. Study Figure 200 very carefully.

The Spinal Cord in Reflex Action. If we take a frog that has just been killed by the removal of the whole brain, we find that the spinal cord can act as the medulla does in completing certain nerve circuits. If we irritate the chest of the brainless frog, the front legs move to scratch at the irritated part; or if the skin of the toe is irritated, the foot is jerked away. It appears, then, that nerve impulses pass into the spinal cord from the outside (from the chest or the foot, for example), and that impulses pass out again from it to the muscles to relieve the irritated part. Such a response to impulses from the outside is called *reflex action.*

If, now, the spinal cord of the dead frog is also destroyed, there is no response to irritation of the chest or the foot. This proves that the spinal cord is the necessary central station that receives incoming messages and sends the proper message back down the outgoing nerve to the muscles. In other words, the spinal cord is the *center of reflex action.*

Two Kinds of Nerve Fibers. When you will to move your first finger, you send an impulse to the muscles that move it, and the finger moves. When you touch an object with the finger, you feel the object; this time a different impulse passes along the nerve. One kind of impulse goes out from the center to a muscle and results in motion. It is called a *motor* impulse, and it uses a special set of nerve cells and their fibers, which are therefore called *motor cells* and *motor fibers*. The other kind of impulse comes from outside to the center; and if carried as far as the brain causes us to feel, this is called a *sensory impulse*. It begins in sensory fibers and ends in relay cells located in the spinal cord, which sent it on to the brain.

Most nerves consist of motor and sensory fibers bundled up together. In reflex action the sensory impulse does not pass all the way to the cerebrum, but after entering the spinal cord (or medulla) is at once returned as a motor impulse running along motor fibers to the proper muscle.

An Example of Reflex Action. You have noticed that when you touch the point of a tack unawares, your finger is withdrawn by reflex action before you think. The paths along which the impulses travel to bring about this

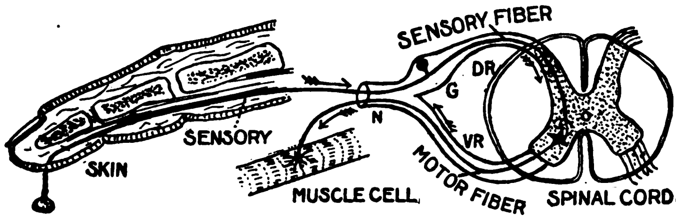


Figure 201. — Diagram illustrating path of nerve impulses in reflex action involving voluntary muscles.

reflex action are as follows (study Fig. 201): The sensory impulse started by the tack passes along sensory fibers to the spinal nerve, then through the dorsal root and the dorsal ganglion to sensory or receiving nerve cells in the gray matter of the spinal cord. Immediately the impulse passes to motor cells in the ventral ridge of the gray matter and then out through the ventral root of the spinal nerve along motor fibers to the muscles of the arm or hand. This is the simplest machinery of reflex action.

It works so perfectly that the impulses are always sent back to the muscles that are best suited to remove the part in danger of being injured. This perfection of reflex action we must attribute to the wonderful power of the cells in the gray matter to select the particular nerve fibers that carry the motor impulses to the proper muscles.

Quickness of Reflex Action. When the sensory impulse, caused by touching the point of a tack, reaches the spinal cord, it is also passed on to fibers leading to the brain (cerebrum). Here it causes conscious sensation; that is, it makes you feel. After thinking it over, you would will to remove the finger from the tack. But this far-around way takes so long that much harm would be done to the finger by the tack before you could think it over. The circuit through the spinal cord, as described in the preceding paragraph, is more rapid. We may say, then, that the principal purpose of reflex action is to protect the body.

The Cranial Nerves. The head is supplied with nerves that start off from the brain. They are called the *cranial nerves* and correspond in many ways to the spinal nerves,

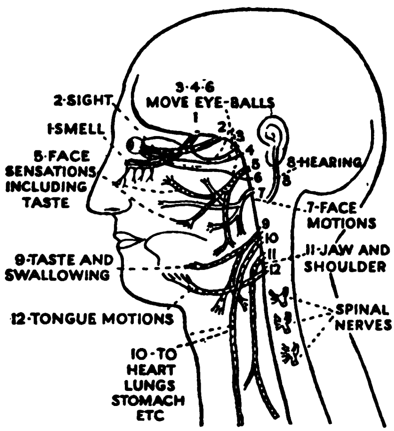


Figure 202. — Diagram showing the twelve cranial nerves.

which supply the trunk and the limbs. The cranial nerves contain sensory or motor fibers or both. The nerves of smell, taste, sight, and hearing are sensory cranial nerves. Three pairs of nerves control the movements of the eyeball. When you have toothache, impulses pass to the brain along a cranial nerve. When you move the jaw in chewing, or wink the eye or use the tongue, motor impulses pass out through other cranial nerves. One pair of cranial nerves, however, passes out of the head into the trunk and controls the vital organs the heart, lungs, stomach, and intestines (see Figure 202).

The Sympathetic Nervous System. Besides the brain and the spinal cord and the cranial and the spinal nerves, there are other nerves and ganglia. These make up the *sympathetic nervous system*. This consists of two chains of ganglia on the dorsal wall of the chest and abdomen, one chain on each side of the spinal cord and close to the backbone. The left one is shown in Figure 203, the right one in Figure 199. There are, in addition to the chains of ganglia, scattered ganglia and bunches of nerve fibers called *plexuses* near and even within the organs of the chest and abdomen, especially the heart and the stomach. A blow over the stomach, where the *solar plexus* is situated, paralyzes the nerves there and may cause sudden death.

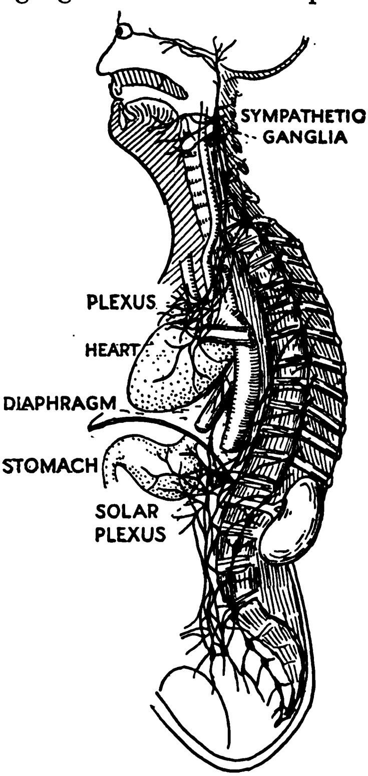


Figure 203. — The sympathetic ganglia and nerves of the left side of the body.

Function of the Sympathetic Nerves. The sympathetic nerves are closely connected by fibers with the central nervous system. They are like the fibers of the spinal nerves in that they carry impulses in and out of the spinal cord. They take part in reflex action which involves the involuntary muscles; that is, the heart and all muscles composed of smooth fibers. The sympathetic nerves, therefore, help to regulate the heart-beat, cause movements of the alimentary canal, etc. In short, they aid in the control of what we might call the vital functions, or those processes in the body on which life depends.

Further Examples. When we begin to exercise, our heart-beat and breathing become more rapid. Soon the skin becomes red and the sweat glands begin to secrete. After we have exercised a while, impulses of heat are sent from the skin along sensory fibers to the central nervous system. Then impulses are sent out through the sympathetic system, which brings about the events that happen in the body on account of exercise.

Another example of such a reflex act, which you may readily observe for yourself, is the change in size of the pupil of the eye. There are smooth muscle fibers in the colored ring, or iris, around the pupil of the eye. When these muscles contract, the pupil becomes smaller. This happens by reflex action when a bright light shines into the eye. In the dark the pupil is larger, for then the muscles of the iris relax. This action may be observed in the following experiment:

EXPERIMENT. Hold a mirror before you and examine the pupil of the eye. Note its size. Now close the eye a moment and open it suddenly. As you raise the eyelid, note that the pupil is larger than when at first observed, and that it very quickly becomes smaller. Explain the reflex action.

Reflex Action of the Glands. Besides controlling the involuntary muscles, the sympathetic system controls the work of the glands. During exercise, for example, the sweat glands secrete without our willing them to do so. We have also learned that taste and chewing of food cause the secretion of saliva and gastric juice, the "appetite" juices. Secretion and excretion are, therefore, also reflex acts.

SUMMARY

The spinal cord has two main functions. First, it carries sensory impulses from the outside to the brain and motor impulses from the brain to the outside. It is a cable of fibers, and there are relay stations on the way. The fibers are located in the white matter of the cord and in thirty-one pairs of spinal nerves and their roots; the nerve cells are the relay stations and are found in the gray matter of the cord and in the dorsal ganglia of the spinal nerves.

Second, the spinal cord, acts as a reflex center; that is, it is able to receive sensory impulses and translate them into motor impulses. This may be called the short circuit of reflex and unconscious action, as distinguished from the long circuit through the cord and the brain, which results in conscious action.

There are twelve pairs of cranial nerves starting off directly from the brain. These nerves include among others the important nerves of sight, hearing, taste and smell, and one pair of nerves that help the sympathetic system in the control of the heart-beat and the work of the digestive organs.

The heart and all the organs having smooth muscle fibers are controlled mainly by the sympathetic nervous system. This consists of ganglia and nerve fibers that communicate with the central nervous system. The sympathetic nerves carry stimuli that cause the glands to secrete and also cause the reflex action of the involuntary muscles. The sympathetic nerves therefore control those acts on which at every moment the very life depends.

QUESTIONS

1. Where in the body are the organs pictured in Figure 199 located? 2. With Figure 200 before you, describe the structure of the spinal cord. 3. In what direction do impulses pass along motor fibers? Along sensory fibers? 4. Draw Figure 201 on the blackboard and explain the course of sensory and motor impulses in and out of the spinal cord. 5. Explain how it is that a frog with its head cut off will still draw up its leg when its foot is irritated. 6. Give three examples of reflex action. 7. What is meant by reflex action? 8. Why is reflex action quicker than conscious action? 9. What two

kinds of muscles are there? 10. Which of these is controlled by the sympathetic nerves? 11. Where are the sympathetic ganglia situated? 12. What nerves cause the salivary glands to act? 13. What are the cranial nerves and what parts of the body do they control? 14. Give an example of reflex action in which the nerve impulses must pass along cranial nerves.

CHAPTER XLIX. TRAINING OF THE NERVOUS SYSTEM

In Chapter XLVII we learned that the cerebrum is the part of the brain with which we remember, think, will, and feel. The lower nerve centers (sympathetic, spinal cord, medulla, and cerebellum) control many actions, thus leaving the cerebrum free to carry on the higher functions of the mind. We shall see how the cerebrum is naturally relieved from attention to reflex acts, and how we can train the different parts of the nervous system to become the ready servants of our will.

Advantages of Reflex Acts of Involuntary Muscles and Glands. It is very plain that it would be impossible for a person to regulate the heart-beat, the breathing movements, the movements of the intestines, and the secretion of sweat and of the digestive juices, by acts of the will, all at the right time and in the right degree. If the cerebrum had to regulate all these acts necessary for life, we could not do or think about anything else. As it is actually arranged, the cerebrum is free to perform the higher functions, leaving automatic acts to be performed in part by the sympathetic system and in part by the medulla. Such reflex acts are more perfectly performed for the very reason that they are automatic. They are as perfect in babies and in animals as they are in grown people.

Advantages of Reflex Action of the Voluntary Muscles. One of the advantages of ordinary reflex action of the voluntary muscles was pointed out in the last chapter. You can move the muscles of the arm at will; yet in reflex action the arm is moved without your willing to do so, as when you touch the point of a pin or a hot stove. Reflex action is more rapid than voluntary action and is, therefore, of value to the body in protecting it against sudden harm.

Observation Work. Name six ways in which reflex action has been a protection to you during the past week.

The movement of voluntary muscles by reflex action also spares the cerebrum. Many acts are done reflexly and without the necessity of conscious attention. Thus, when we eat, we swallow our food without thinking about swallowing. The act of swallowing is a reflex act.

Habit. There are many acts in life that are very hard to do at first but become easy later on. The child learning to walk must give his whole attention to the act. Later, walking becomes so easy that we walk without even thinking about it. So it is with many other acts. The oftener any act is repeated, the easier it becomes and the more one tends to do the act. We say it becomes a *habit*.

Value of Habit. Before the habit is formed we must give our whole attention to the act. Washing, dressing, eating, writing, and a thousand other things that we do every day are difficult until we have done them often. In other words, the cerebrum has hard work at first in training the muscles to do the right thing at the right time. Later, the cerebrum has less and less to do with the act, the lower centers taking charge of the business. Finally we perform habitual movements without even knowing that we are moving.

For these reasons habit is a great aid to the mind. The more habits we form, the less work the cerebrum has to do with the petty acts of life and the more attention can be given to thinking about things more worth while.

Practise. Practise makes perfect. When you first try to tie your necktie, you can do it neither easily nor neatly. With practise, however, come ease and skill. It is important early in life to learn to do well as many useful things as possible. Thus, when the multiplication table is once learned, that much of life's work is laid aside. We should learn to read, write, spell, think accurately, develop skill in using the hands, and do as many other things as possible while we are young. When we are grown these things can be performed unconsciously, leaving the cerebrum free to give attention to more difficult acts.

Education. The formation of right habits of thinking and acting is a large part of the work of education. This fact makes education in the home and the school very important. Every day possible should be spent at school. The person who has many good habits and who has the ability to do many things easily and well is the person who is most likely to be successful in life.

EXPERIMENT. Write the word Practise on a white sheet of paper. You write it easily and without thinking how each letter is made or how the word is spelled. Now copy immediately below the word just written the characters in Figure 204, turn the sheet around, and hold it up to the light. Why did you write the first more easily than the second? A child who has never written a word would find it more difficult to write the word Practise than you find it to write the characters in Figure 204, which is a mirror image of the word Practise.

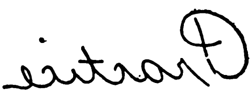


Figure 204.

Breaking Bad Habits. It is as easy to form a bad habit as a good one. Biting the finger nails, speaking evil of others, and neglecting the teeth are bad habits. Habits are hard to break. It is difficult, the first time we try, to keep from doing any act that has become habitual; but the second time we abstain from doing the act it is easier, and so on until it becomes a habit to abstain from the act. It is best to acquire good habits and never to form bad ones. A person with many good habits will be more successful in life than a person with bad habits or too few good ones.

SUMMARY

The reflex acts of secretion and of the movements of smooth muscles are involuntary and the cerebrum is freed from giving attention to them. Such acts are not subject to education and are as perfect in babies and in animals as they are in grown people. Ordinary reflex acts of the voluntary muscles are quicker than voluntary acts and therefore are protective to the body. All reflex acts that are performed unconsciously (as swallowing, for example) relieve the cerebrum from the work of controlling them.

Many complicated acts of life, that call into action many voluntary muscles, such as walking, are difficult at first and require much work on the part of the cerebrum. With practise these acts become more like reflex acts and require the attention of the cerebrum less and less the oftener they are performed.

Such acts of life, that have to be learned by the training of the nervous system, are habits. There are good habits and bad habits. Education is intended to increase the number of good habits and keep down the number of bad ones. A person is likely to be successful and happy if he has formed many good, and few bad, habits in youth.

QUESTIONS

1. What are the functions of the cerebrum? 2. What are the acts not controlled by the cerebrum? 3. Why would it not be well for us to have to control our heart-beat consciously? 4. Describe an experiment illustrating the action of an involuntary muscle. 5. Why does the cerebrum have no direct control over the secretion of the glands? 6. Do you think of swallowing all the time that you are eating? Why not? 7. State two advantages of reflex action. 8. What is a habit? 9. Name five good habits. Three bad habits. 10. What is the value of habit? 11. Why does practise make perfect? 12. Why should education be obtained in youth? 13. How can we train the nervous system? 14. How are bad habits broken?

CHAPTER L. THE CARE OF THE NERVOUS SYSTEM

The nervous system is the most wonderful and the most delicate part of the human body. It is also more closely connected with our real selves than any other part. The nervous system not only coördinates all our organs, as has been pointed out in Chapter XLVI, but also regulates our relations with the world around us. The care of the nervous system, therefore, becomes the most important problem of hygiene. The man who solves the problem of how to keep an active efficient nervous system has largely solved the problem of correct living.

This is a difficult task, and you cannot expect to learn all about it in a single year. Indeed, you must learn a great deal from experience. In this book we can only hint at some of the important points to bear in mind with reference to the nervous system. These points we may summarize in the following rules: (1) Keep the body in general good health according to the rules of hygiene thus far learned; (2) avoid all stimulants except when they are prescribed by a physician in case of sickness; (3) form good habits; (4) avoid the poisoning which results from germ diseases such as typhoid fever, scarlet fever, grip, and others; (5) keep the stomach in good order; (6) avoid worry, overwork, and mental strain; (7) sleep sufficiently; (8) take enough recreation.

Habits. We shall take up first the subject of habits, as stimulants are discussed in the next chapter. Habits are physical as well as mental and moral. Among bad habits may be mentioned that of spitting on the floor, which is, of course, a physical habit. A bad mental habit is that of giving poor attention to one's studies. Giving way to fits of anger is a bad habit, both from a moral and a physical standpoint. The sum total of a man's habits forms his *character*. Most people have more good habits than bad ones, and would have fewer bad habits if they realized how easy it is to prevent a habit if one begins in time.

People desire the best habits, even from a selfish point of view, as soon as they come to realize how much more of joy in this world good habits bring.

Effect of Germ Diseases on the Nervous System. We often see young people so weakened by an attack of disease, such as typhoid fever for instance, that it is years before they can perform their ordinary duties with comfort. All the germ diseases set poisons free in our blood. These poisons injure the delicate nerve cells. While it is not an everyday occurrence to see insanity as a result of smallpox or typhoid fever, such things do occur. You can imagine, then, the terrible harm that can result to the nervous system, when a patient lies for weeks in a delirium due to the poisons of typhoid fever. Many nervous diseases are caused by germ diseases, and if we prevent the germ diseases, we prevent the nervous diseases which follow.

Figure 205.— All the catching diseases leave the nervous system weakened to a greater or less degree.

Effect of the Stomach on the Nervous System. The stomach is very richly supplied with nerves, both from the brain and from the sympathetic system. The solar plexus (Fig. 203) supplies many nerves to the stomach. The close connection between the stomach and the nervous system is shown by the fact that fright can make some people sick at the stomach, or nauseate them. Strong excitement or anger interferes with appetite and digestion. For this reason only pleasant topics should be discussed at meal time. If we are careless in our eating habits, and swallow food hurriedly, or eat at irregular hours, or fail to masticate our food properly, it is very likely to upset the stomach and make us nervous and miserable. There is one kind of dyspepsia that is called nervous dyspepsia; few people are so miserable as those who suffer in this way.

Overwork. A reasonable amount of work helps to keep the body in good condition and makes a person enjoy his leisure and his sleep. But this work must be regulated according to the strength of the worker. One man can stand twice as much work as some other man. It is said of some men that they can work eighteen hours a day for many days at a time. This is probably not true. It is certain that such a practise would wear out an average man in a short time. Some people of delicate constitution can work only an hour or two at a time without being fatigued. When one works too long or too hard, he notices that he cannot do quite as good work as usual, and that he does not enjoy his work as much. If he keeps on trying to drive himself to work as hard as ever, he finds that he is depressed and becomes discouraged easily. He gets what is called the blues, and becomes more irritable than is his habit. He is likely to become nervous and sleepless, and may lose weight. He feels tired, even on rising in the morning, and spends a very miserable existence indeed.

Figure 206. — This represents a man who has been overworked.

It is often difficult to say whether a boy is overworked or whether he is merely lazy. One indication of laziness is that the individual is interested in something outside of his work, a thing not likely to be the case with an overworked boy. We should remember, however, that people of an enthusiastic, eager disposition are more likely to overwork themselves than those of a reserved, smooth temperament. If you are of an enthusiastic disposition, there may be times when you feel overworked, and in these times you should talk with some older person, such as a parent, sister, or guardian. Oftentimes an outsider can plainly see what we ourselves overlook.

A nervous breakdown resulting from overwork is a serious matter. The cure for it is a change of scene and habits, which is expensive. Hence it is wise to avoid a breakdown. Longer hours for sleep and recreation, and more cautious use of exercise, should be begun as soon as signs of a nervous breakdown occur.

Figure 207. — Sleep is the greatest restorer of worn-out nervous systems.

Sleep. One who sleeps enough is not likely to suffer a nervous breakdown. Sleep is the cure for worry and overwork. A child of twelve should sleep from nine to eleven hours a day. A man doing hard physical labor should sleep at least eight hours a day. Intellectual laborers should sleep an hour more. Those who have a delicate constitution should take a nap in the middle of the day, especially in warm weather.

Recreation. This is next to sleep in importance. Every man needs some exercise which he can take with so much pleasure that he forgets himself. The true test of recreation is, that it cause the player to forget himself in the enjoyment. Men who perform hard physical labor usually like some recreation which employs the mind more than the body, such as music or reading. Intellectual workers usually prefer some form of recreation which calls the muscles into play, such as tennis, golf, or hunting. Exercise for the sole purpose of building up the body, especially if it is unpleasant, is not true recreation. To get the most good out of recreation, it must be enjoyable. In Texas the climate is such that outdoor exercise can be enjoyed all the year round, and all persons who have a nervous tendency should try to spend a large part of the time out-of-doors. It is nearly always possible to find a congenial occupation out-of-doors.

The Nerve Cells. The nerve cells are the seat of those nervous changes which go to make up our conscious life. When the nerve cells are well nourished and fresh, we feel well; when the nerve cells are tired, exhausted, or starved, we feel ill. The nerve cells are so delicate that we cannot handle them after death without destroying

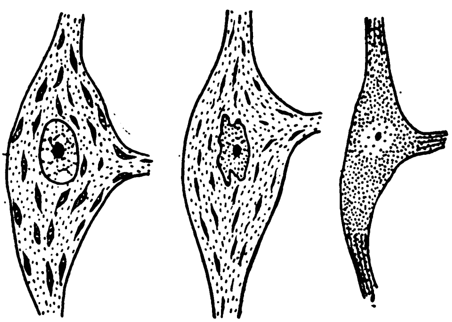


Figure 208. — The picture to the left is a fresh, unfatigued nerve-cell. The middle picture is a moderately fatigued nerve-cell. The picture to the right is a nerve-cell poisoned by alcohol or disease.

them, and so, up to this time, we have never seen many of the changes which occur in them as a result of fatigue or of poisoning.

The results of fatigue are best seen in the cells of animals which are hard at work all day, such as the bee or the swallow. If the nerve cells of these little beings are examined at night, they appear shrunken and irregular in outline. In the morning, while the little creatures are fresh and strong, the nerve cells seem to be well rounded out. This is shown in Figure 208. We know, then, that we cannot do good work with worn-out or poisoned nerve cells. Disease germs, alcohol, or morphin cause poisoning of the nerve cells. Rest, recreation, and sleep restore the cells to their proper strength and vigor.

Just as the mind is the highest function of the nervous system, so the judgment is the highest faculty of the mind. At no point do we need good minds and good judgment more than in the regulation of our lives so as to keep our nervous system in good order.

IMPORTANT POINTS

The enemies of a good nervous system are as follows:

1. General poor health from other causes.
2. Stimulants, such as alcohol, tea, and coffee.
3. Bad habits, and excesses of all kinds.
4. Germ diseases such as typhoid fever.
5. Improper habits of eating, causing imperfect digestion.
6. Worry, overwork, and mental strain.
7. Lack of sleep and lack of recreation.

QUESTIONS

1. Name some stimulants which may cause nervous disease. 2. Name all the germ diseases you know. 3. Name some bad habits. 4. Explain why the stomach is concerned in nervous disorders. 5. Explain the importance of sleep. 6. Explain what is meant by recreation. 7. If a man practises with dumb-bells in order to gain muscle, is this recreation? 8. How, then, can you tell whether an exercise is true recreation or not? 9. What is the difference between the nerve cells of a bee early in the morning and at the close of a busy day? 10. What kind of persons are likely to be overworked?

CHAPTER LI. ALCOHOL, NARCOTICS, AND STIMULANTS

We have already learned that the poisonous liquid or drug called *alcohol* can injure the various organs of the body; but this poison acts in such a stealthy and peculiar way that we shall devote some time now to the study of the poison itself, of its effects on the human body, and of how to avoid it.

Alcohol. Pure alcohol is a clear, colorless liquid, somewhat lighter than water. It mixes with water very readily. Alcohol evaporates rapidly, and for this reason, when placed on the skin, the skin feels cool as it evaporates into the air. If it is placed on the skin and then covered, however, it feels hot and causes reddening of the skin.

Alcohol is made from fermenting sugars. In the process of making alcohol, the yeast germs change the sugar to alcohol, and in so doing they cause carbon dioxid to bubble out of the fluid. If the yeast germs are allowed to remain in the water and sugar solution, there comes a time when they have formed so much alcohol that they can no longer live in the mixture, and they die. Other germs are less able to live in the alcohol solution than the yeast germs.

From this it might be supposed that alcohol is good for us, because it kills germs. But in the chapter on disinfectants we have learned that if we desire to kill germs in the human body we must use something that is more poisonous for the germs than for our bodies. Alcohol is just as poisonous for us as it is for the germs, and indeed it gives the germs the advantage by upsetting our system. So it is not a useful drug for killing germs in the human body.

Percentage of Alcohol in Whisky, Beer, and Wine. We have learned that pure alcohol is a clear liquid; but the drinks sold to the public do not usually contain more than fifty per cent of pure alcohol. Whisky and brandy contain about fifty per cent, the wines from seven to twenty per cent, and beer from one to five per cent of alcohol. Practically all that any of these liquors contains in addition to the alcohol is some sugar and flavoring and coloring matter. The picture shows that the quantity of pure alcohol contained in an ordinary drink of whisky is about the same as that contained in a drink of beer or wine.

It is most remarkable how this alcohol attacks every organ of the body with which it comes in contact.

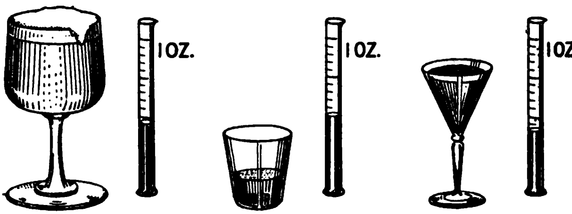


Figure 209. — Although beer and wine contain a lower percentage of alcohol than whisky, a drink of beer contains about the same amount of alcohol as a drink of whisky. The tall graduated glasses represent the amount of absolute alcohol in a single drink of beer, whisky, and wine.

Effects of Alcohol on the Stomach and Liver. The stomach is very badly affected by alcohol, and it becomes inflamed from the irritating action of liquors containing this poison. Indigestion, loss of weight, and a general condition of invalidism, are signs of the bad effects which the alcohol has on this particular organ. The liver also feels the presence of alcohol, and shows it by becoming tough and fibrous from the scar tissue or connective tissue which is caused by alcohol. When this has once developed, there is no hope that the patient will ever recover. As a rule the drinker does not know he is threatened with this trouble until it is too late.

Effects of Alcohol on the Respiratory System. The fumes or odor of alcohol can be detected in the breath, which means that the lungs are doing their part to throw the poison out of the system. Alcohol makes people susceptible to the inflammations of the lungs, such as pneumonia. Persons who drink alcohol succumb more easily to pneumonia than persons who drink no alcohol. Whenever physicians are called in to treat a case of pneumonia, they always inquire if the patient is a user of alcohol. This disease is dangerous at any time, but especially so when it occurs in drinkers.

Effect of Alcohol on the Kidneys. The kidneys help the lungs to rid the system of alcohol, and in throwing this poison off, the kidneys are somewhat injured. They are often so injured that they can never be repaired; usually when a drinker has caused nephritis or kidney disease by his bad habits, it is too late to remedy the matter. Nephritis means an injury of the little kidney cells (*XYZ*, Fig. 159). Like the liver cells, the kidney cells, when they are inflamed, are replaced to some extent by connective tissue.

Effect of Alcohol on the Heart. Drinking alcoholic liquors injures the heart, because the liquid has to be pumped to the lungs and to the kidneys, to be thrown off from the body. The heart is thus made to pump more blood than the needs of the body demand; and it seems reasonable to suppose that a heart is overloaded when one drinks much liquor. The alcohol in the blood also hardens the arteries and causes the growth of scar tissue, which can be seen in spots in the arteries after death. Hardened arteries sometimes burst, and when such a vessel ruptures in the brain, it causes the disease known as apoplexy.

Effect of Alcohol on Muscles and Bones. The muscles and bones are injured by alcohol, because they suffer from want of food. If the stomach is inflamed, it cannot prepare food for the needs of the body, and for this reason persons who drink large quantities of alcohol are usually weak and feeble.

Effect of Alcohol on the Nervous System. The nervous system is so delicate that it must be taken care of properly or it will certainly get out of order. The most wonderful watch that was ever made, when compared with the human nervous system, is as clumsy and awkward as an ox wagon. The delicate machinery of brain, spinal cord, and nerves has to do with the proper control of our organs and also with our thoughts. Think what dreadful consequences must follow the injury to these little cells which form our thoughts. More cases of insanity are caused by alcohol than by anything else except heredity. Probably about twenty per cent of all insanity is due entirely to alcohol.

How the Drink Habit is Formed. It is not stated anywhere in this book that all persons who use alcohol will develop any of the diseases mentioned. Indeed, there are some people who do not seem to be injured by alcohol, so far as we can tell. Such persons are to be compared with typhoid carriers. You remember that some persons have the typhoid germs in their bodies without showing any symptoms of the disease. These persons are well and strong, and so far as they are concerned, are none the worse off for having the germs; but they spread the disease to others. So it is with drinkers: some of them take the alcohol into their systems without showing any immediate ill effects on themselves, but they spread the drink habit. Young men and boys see them drink and follow their example. In the case of germ diseases, a person who has a mild case may give the disease in its worst form to another person; so a man who drinks just a little can give the germs of the habit to another man, who may drink himself into his grave or into the asylum.

Possible Effects of the First Drink. Probably all of you know now how alcohol can **ruin** its victim. You have no doubt heard of, or possibly seen, a drunkard, with his staggering gait, his unkempt hair, and his bleary eyes. Such a poor drunkard goes about exposing himself to the weather, and leaves his family to look out for themselves. He is not himself, and that marvelously beautiful instrument, the brain, is in such poor working order that he is little better than an idiot. A drunkard may scowl at his best friend as though he hated him, or may speak roughly to a little child; on the other hand, he may look on a scene of sadness and chuckle as if it were a joke. You may be sure that no man ever expected to be anything like this

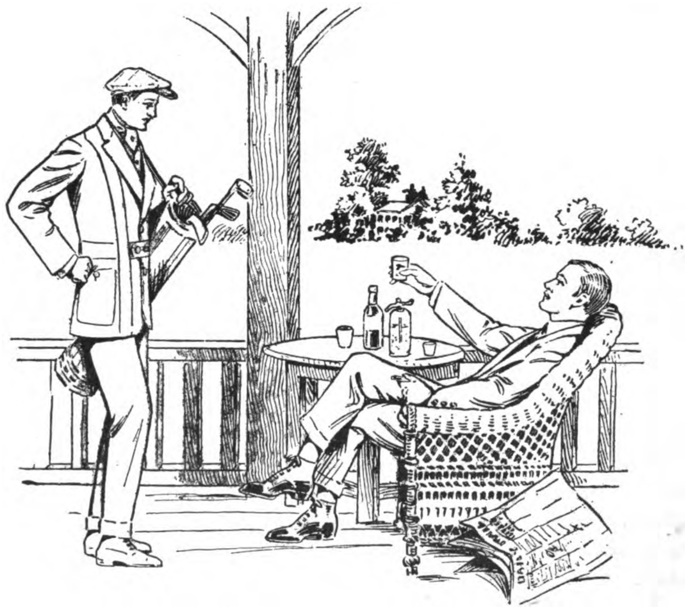


Figure 210. — The first drink is almost always taken to accommodate a friend. Have your mind made up beforehand never to take the first drink.

when he took his first drink. And yet it is impossible to tell beforehand just who will develop into a drunkard.

Since, then, alcoholic drinks are absolutely worthless to the user, and may cause irreparable harm to body and mind, it is best never to begin to drink. When invited by a friend to drink with him, it takes strength of mind and force of character to refuse to be led into so dangerous a habit. Make up your mind that, when you are in the situation of the young man shown in Figure 210, you will decline.

Effect of Alcohol on Business Success. For business reasons it is wise to leave alcohol absolutely alone, for many firms will not employ any one who drinks. This is true especially of banks, railways, and other business concerns which are entrusted with people's property or people's lives. Athletes who are ambitious to excel always leave alcohol alone when preparing for a contest. Locomotive engineers must not drink, for the lives of the passengers are in their hands. Lawyers must work hard at times, and sometimes an innocent man's life depends on the good work of the lawyer who is defending him; in a case of this kind alcohol is a hindrance. The physician fighting disease cannot afford to drink, as it would make him unfit to give advice to the patient depending on him. The machinist cannot afford to drink, for if his nerve is unsteady he may lose a finger or suffer some other painful and mutilating accident. The salesman in a store cannot afford to drink, for he must receive money and return the change quickly and accurately. The stenographer dares not drink, for he may write an error into an important letter. Indeed, it may be said that any good work demands of a man that he leave alcohol alone. Drinking is out of place in the life of any man.

Tea and Coffee. Somewhat akin to the alcohol question, but of less importance, is the tea and coffee problem. Both tea and coffee contain a substance which in its pure form exists as white crystals, called *thein* or *caffein*. This substance acts as a powerful stimulant to the muscles, the nerves, and the mind. After the first effect passes off, the drug causes depression and discomfort. In mild doses it is not very harmful to some people, but it is always risky to tamper with stimulants. In the long run, any man can do more work without stimulants than with them. It is rather cowardly to take stimulants in order to stand up under a special strain. A man should face his trials manfully, whether they are an extra hard day's work, a tedious examination, or some other hard task. The use of stimulants to give a man temporary strength to perform his duty undermines his self-reliance.

Opiates. There is a drug that affects another part of the brain, and this drug is opium or morphin. Opium is the dried juice of the poppy, and morphin is a white crystalline substance which represents the strength of opium. Opium and morphin do not increase the intellectual powers, but they stimulate the imagination and relieve pain. These drugs are even more deadly than alcohol, because they almost invariably cause the opium or morphin habit. You can have no idea how these drugs cause one to long for them after one has taken them a few times. When the first effect wears off and the dreadful after-effect comes on, the user of the morphin is nervous and miserable, and frequently takes his own life.

The morphin habit is very hard to shake off. It is against the law for such drugs as morphin to be sold in Texas except on a physician's prescription, and all conscientious physicians take precautions in the use of these deadly drugs, in order to prevent their patients from forming the habit. Laudanum, paregoric, Dover's powder, cocain, and some headache powders or capsules, belong in the same class. It would be well for you to make it a rule never to take any medicine to relieve pain except on the advice of a competent physician.

IMPORTANT POINTS

1. There was never a drunkard who believed at the time he took his first drink that he would become a drunkard.
2. Alcohol injures all the organs of the human body, but does its greatest harm to character.
3. The first drink is usually taken to please a friend.

4. Tea and coffee act as stimulants, but in the long run do not increase one's ability to perform work.

5. We should avoid taking morphin, opium, soothing sirups, and headache powders or capsules for the relief of pain.

QUESTIONS

1. What is alcohol? 2. Alcohol does not help the body destroy germs, although alcohol itself will kill germs. Why is this? 3. In what way does alcohol do its greatest harm to the body? 4. Since beer contains a smaller percentage of alcohol than whisky, explain why it is that a drink of beer contains as much alcohol as a drink of whisky. 5. Why should physicians let alcohol alone? 6. Why should a salesman let alcohol alone? 7. Name three other types of persons who cannot afford to drink alcohol in any form. 8. Is there any business in which a drunkard is likely to succeed? 9. Why is it dangerous to take medicine freely to relieve pain?

CHAPTER LII. THE SPECIAL SENSES: TOUCH

General Sensations. We have learned (Chapter XLVIII) that there are two kinds of nerve fibers: sensory fibers, carrying impulses in to the central nervous system, and motor fibers, carrying impulses out to the muscles. In reflex action, sensory impulses may pass only to the spinal cord, and be there changed to motor impulses that pass out to the muscles. If the sensory impulses reach the cerebrum, they result in sensations. When meal time arrives we are hungry; if water is needed, we are thirsty. Hunger and thirst are sensations due to impulses that arise from all parts of the body. They are, therefore, called *general sensations*. Feelings of fatigue and of nausea are other general sensations. General sensations are useful in serving as a guide to the general condition of the body.

The Special Senses. The special senses (touch, taste, smell, sight, hearing) differ from the general sensations in that each has a special organ that produces a particular kind of sensation. Thus the skin is the organ of touch, the nose of smell, the eyes of sight, and the ears of hearing. These organs are called *the organs of the special senses*, by which we feel, taste, smell, see, and hear. Through the special senses we learn all we know about the things around us. Since this is true, it is very important that we train the senses so that they may, through practise and habit, become our skilful servants.

Four Conditions Needed for Sensations. In studying the special senses we must remember that, in order that a sensation may be produced, a number of things are necessary. (1) There must be a proper *stimulus*, for without something touching the skin we could not feel, or without light we could not see. (2) There must be *cells* (the *end cells*) in the sense organ to catch up these stimuli, magnify them, and translate them into nerve language and pass them on. (3) From the end cells *sensory nerve fibers* must take the nerve impulse to the brain. (4) The cortex of the cerebrum must be active, so as to receive the impulse and produce the sensation. If any one of these four is absent or injured, there can be no sensation. In studying the sense organs we shall make it a point to study the situation of the end cells and to discover how the various stimuli reach them.

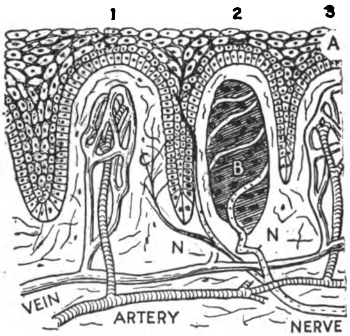


Figure 211. — Papillæ of the skin; *A*, epidermis; 1 and 3, papillæ with blood vessels; 2, papilla with touch bud.

Touch. The skin is the organ of touch. As shown in Figure 161, and again in *B*, Figure 211, there are groups of cells called *touch buds*, among the cells in which the sensory nerve fibers end. When an object touches the skin, it presses against the touch buds and stimulates the nerve fibers; the impulses are then carried to the brain and we have the sensation of touch. If the pressure is even over the skin, we feel the object as smooth; if the pressure is greater in spots, we feel the object as rough. Hard, soft, sharp, dull, etc., are words that describe how objects feel from the way they press against the skin.

Experiments on the Sense of Touch. (1) Some parts of the skin are more sensitive to pressure than others, as can be readily observed by experiment. Take a bristle from a whisk-broom or clothes-brush and press it against the skin of the nose, forehead, lips, back of neck, tips of fingers, etc. (2) Another test for sensitiveness of touch can be made by finding out the greatest distance apart two points, pressing on the skin at the same time, will be felt as one point. Take a pair of blunt scissors and place the two points, separated one sixteenth of an inch, on the tips of the fingers of a person, who should have his eyes shut or be looking away. Are they felt as one point or as two? Repeat the experiment for different regions of the skin, separating the points more or less; on the back of the neck the points may be several inches apart and still felt as one point. Try this on different persons, but try to confuse the person experimented upon by alternating the application of a single point and of two points.

The Temperature Sense. At some places in the skin certain nerve fibers end in cells that are not a part of touch buds. Many of these fibers carry sense impulses of heat and cold. The ability to feel differences in temperature is known as the *temperature sense.*

SUMMARY

A person is capable of feeling general and special sensations. Hunger and fatigue are general sensations which do not come from special organs. The special senses are those of touch, taste, smell, hearing, and sight. Certain organs can be designated as the organs of the special senses: the skin, the tongue, the nose, the ears, and the eyes. In these organs are special cells, the end cells, whose duty it is to take up the stimuli. Objects striking or touching the skin, for example, stimulate the end cells of touch in the touch buds of the skin. These end cells pass the stimuli on to the sensory nerve fibers (the nerves of touch) leading to the cerebrum. Here the stimuli are translated into sensations, and thus we feel. A similar process takes place in all the special senses, as will be seen in the following chapters.

QUESTIONS

1. Mention some general sensations. 2. What is the use of these? 3. Why can you not designate organs of general sensations? 4. Name the special senses and give the organ of each. 5. What is the function of the end cells in the sense organs? 6. What other conditions besides end cells must there be before we can experience sensations? 7. Illustrate this in the case of touch. 8. Where are the end cells of touch situated? 9. What parts of the skin have you found to be most sensitive to touch? 10. What is meant by the temperature sense? 11. Tell the different events that must happen in order that you may have a sensation of touch.

CHAPTER LIII. TASTE AND SMELL

The senses of taste and smell are very much alike. Indeed, many things which we think we taste, we really smell. Thus vanilla flavoring is not tasted but smelled. Sweet, sour, bitter, and salty substances only can be tasted. We distinguish flavors by the sense of smell.

EXPERIMENT. Close your eyes and hold your nose. Now let some one lay on your tongue successively a slice of apple, of potato, and of onion. Can you distinguish them by taste alone?

Organ of Taste. Just as the skin is the organ of touch, the tongue is the organ of taste. Just as there are touch buds in the skin, so there are *taste buds* in the tongue. They are situated on the sides of the elevations or *papillæ* of the tongue. The largest of these papillæ occur in two rows near the back of the tongue, and other smaller ones are scattered over the tongue (Fig. 212). A cross section of one of the large papillæ is shown in Figure 213. The taste buds are seen to consist of long, spindle-shaped cells (1 and 2, Fig. 214), with their points coming together at the taste pores (*P*). Among some of these cells (2) arise fibers of the nerves of taste (*N*), which are branches from certain cranial nerves.

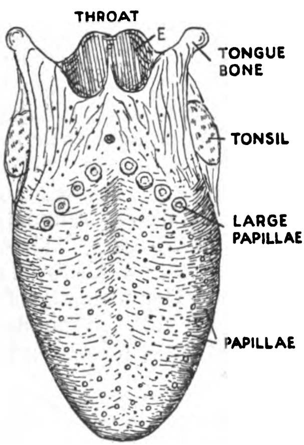


Figure 212. — The tongue.

How we Taste. Substances are tasted by being taken up by the taste cells of the taste buds and a few other taste cells scattered over the tongue. These taste cells in turn stimulate the nerves of taste. Only liquid substances, that is, substances dissolved in water, can be tasted, because only these can be absorbed by the taste cells. The sense of taste is useful in helping to guide

Figure 213. — Section of large papilla of the tongue, showing taste buds (*B*) and nerve of taste (*N*).

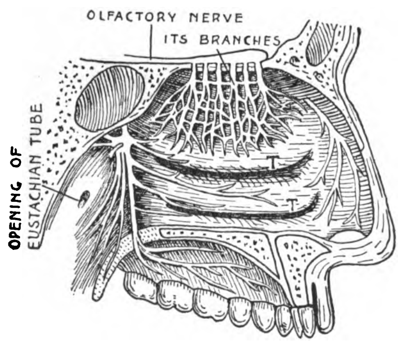
Figure 214. — A taste bud of 213 more enlarged; *P*, taste pore; 2, end cell of taste; 1, supporting cell.

animals in the selection of their food and to stimulate the digestive glands to secrete juices. How does saliva help us to taste starchy food?

Organ of Smell. The nose is the organ of smell. In order that the nerves of smell may be excited, gases or tiny particles floating in the air must enter the nasal passages. Study Figure 121, and note two ways by which odors may pass into the nasal passages. The nerves of smell make up the pair of first cranial or olfactory nerves (1, Figs. 198 and 202). The branches of this nerve are spread out over the irregular inner surface of the nose (Fig. 215) and pass through holes in the base of the skull.

The end cells of smell are situated in the mucous membrane of the nasal cavities. Here are two kinds of cells: long epithelial cells (Fig. 216) and spindle-shaped cells with a long projection at one end and nerve fibers at the other. The cells with the nerve fibers are the smelling cells.

How we Smell. Particles of matter are sniffed in with the air and, striking the ends of the smelling cells, stimulate them. The impulses are passed on to fibers of the olfactory nerves, and thence to the brain. The sense of smell is extremely acute, especially in some animals, such as dogs, and some birds, fishes, and insects. The tiniest particles passing into the nose can stimulate the nerves of smell.



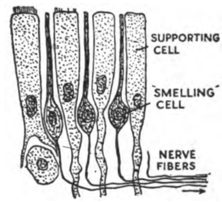


Figure 215. — The nerve of smell at the base of the brain and the branches in the upper part of the left nasal passage.

Figure 216. — The cells of smell from the mucous membrane of the nasal passage.

Use of the Sense of Smell. Smell is a useful sense for it enables us to detect harmful gases in the air, such as fuel gas and odors that indicate disease-breeding objects in our vicinity. Foul odors are disagreeable and warn us when human beings are not cleanly and healthy. The nose is a good detector of impure air in a school room, when a person comes into the room from out-of-doors.

SUMMARY

The end cells of taste are situated chiefly in the papillæ that occur scattered over the tongue. The end cells of smell are special cells among the epithelial cells of the upper part of the nasal passage. The end cells of taste are stimulated by substances in solution in water. The smelling cells are stimulated by the presence of minute particles carried in by the air we breathe. Both of these senses are useful to us in the choice of our food. The sense of smell also enables us to avoid foul and unhealthful places.

QUESTIONS

1. What kind of substances can be tasted only? 2. What substances are smelled? 3. Where are the end cells of taste? Of smell? 4. How does saliva help us to taste? 5. How does taste help to make the saliva flow? 6. How are smell and taste of service to us? 7. Describe how we smell.

CHAPTER LIV. HEARING

Taste is a more delicate sense than touch, and smell is more delicate than taste. Hearing is still more delicate. What is it we hear? Sound, you say. When two objects are struck together, as when a bell is rung, invisible waves of air are produced, called *sound waves*, which radiate out from the center in all directions as waves of water radiate on the surface of a quiet pool when a pebble is thrown into it. The sound waves are caught up and transmitted to certain cells in the ear where the nerve of hearing (*auditory nerve*) ends. Since the hearing organ is so complicated and easily injured, it is encased for protection in the bones of the skull.

The Outer Ear. The ear consists of three parts or regions: the outer, the middle, and the inner ear. The

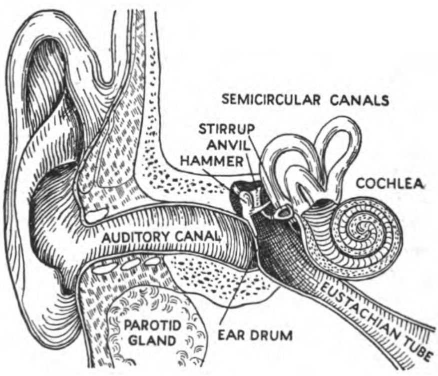


Figure 217. — Diagram of a section of the ear, showing outer, middle and inner ear.

outer ear consists of the shell-shaped outer part which serves to collect the sound waves; and a canal, the *auditory canal* (Fig. 217), which conducts the sound waves to a membrane, the *tympanum* or ear-drum, at its bottom. The tympanum may be likened to a drum-head: when the drum-head is beaten it vibrates; so, too, the tympanum vibrates when the sound waves strike it. Hearing would be imperfect without the tympanum.

Hygiene of the Outer Ear. For protection the ear-drum is set back at the bottom of the auditory canal. For further protection the canal is crooked. There are also glands in it that secrete yellow, bitter wax which keeps insects away from the tympanum. Under no circumstances should any one try to remove objects from the depths of the canal with any hard instrument, for fear of injury to the tympanum. Warm water and a soft cloth are all that is needed in washing out the ears. Should an insect get into one of them, a little warm water poured into the upturned ear is usually sufficient to remove the intruder.

The Middle Ear. The middle ear is likewise hollow, and communicates below through the *Eustachian tube* (Figs. 215 and 217) with the pharynx and through this with the outside world. Thus air can get to the tympanum from both sides. Do you see why this is? Your physical geography teaches that atmospheric pressure varies with the weather. If the pressure were greater or less on the outer, than on the inner, surface of the tympanum, this organ would be stretched, causing pain. Sometimes an ear-drum is broken by air waves caused by a very loud sound, as the report of a cannon. If the Eustachian tube is in good condition, such an accident may probably be prevented by simply opening the mouth when the cannon is discharged.

The Ear-bones. How, then, do the sound waves cross the middle ear? Attached to the tympanum is a bridge of three bones, named from their shape, *hammer*, *anvil*, and *stirrup* (Fig. 217). The hammer is attached to the tympanum, the anvil is in the middle, and the stirrup is next to the inner wall of the middle ear. These bones vibrate with the vibrations of the tympanum, and as they do so the stirrup knocks at the door of the inner ear, causing corresponding vibrations in this organ.

Hygiene of the Middle Ear. Since the cavity of the middle ear communicates with the throat by the Eustachian tube, you can readily see that germs may get into the middle ear from the nose and throat. Diseased tonsils, catarrh, and severe colds may affect the middle ear. Ade-

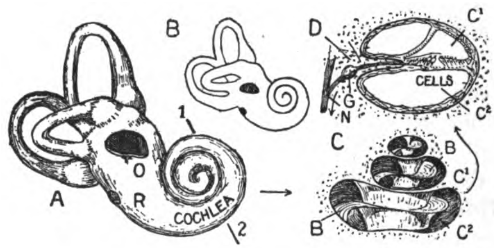


Figure 218. — The inner ear, *A*, as removed from the skull; *B*, same, natural size; *C*, section of cochlea, through line 1–2; *D*, a canal (*c*) of *C*, more enlarged, showing end cells of hearing.

noids in the throat are also frequently the cause of inflammation in the ear. Colds sometimes result in earaches, because the Eustachian tube may become stopped up. This prevents the middle ear from being properly supplied with air.

The Inner Ear. The inner ear is made up of two parts: the *cochlea* and the *semicircular canals*. Of these only the cochlea functions in hearing, for therein are the nerve endings that take up the sound waves.

The Cochlea. *Cochlea* means snail-shell (Fig. 218). As in a snail-shell the hollow winds round and round to the top, so in the cochlea a canal winds round two and one half times to the top and then turns back. There are really two canals, communicating at the top and separated all the way by a partition. The canals are filled with a liquid, a kind of lymph. Now, on the partition between the two canals, there are cells with tiny hairs like projections: these are the end cells of the *auditory nerve*, the cells that catch up sound waves and transmit the impulse to the auditory nerve, which carries it to the cerebrum as the sensation of sound.

How we Hear. How, then, do sound waves from the air about us, reach the hearing cells in the cochlea? First, the air waves strike the tympanum and set it in vibration; this then causes the hammer, anvil, and stirrup to vibrate. The stirrup in turn knocks against the oval window (*O*, Fig. 218) of the cochlea, setting in vibration the lymph

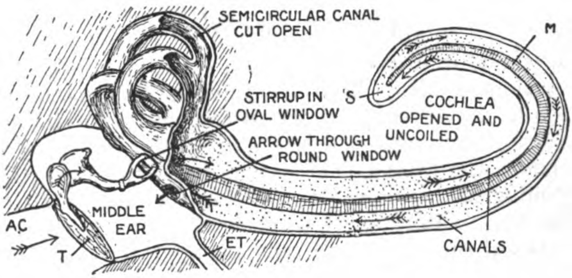


Figure 219. — Diagram showing passage of waves of sound through the ear; *AC*, auditory canal; *T*, ear drum; *ET*, Eustachian tube.

in the canals; the waves of this liquid pass through one canal to the top of the cochlea, then down the other, and finally die out when reaching the end of the canal at the round window of the cochlea (*R*, Fig. 218). This principle is shown in Figure 219, which represents the cochlea uncoiled and stretched out. The arrows indicate the path of the waves. When the lymph is in motion in the canals, it rubs over the hair like projections of the hearing cells (*D*, Fig. 218) and starts impulses that are carried to the brain by the auditory nerve fibers and produces the sensation of sound.

The Semicircular Canals. The semicircular canals are not used in hearing, but they have an important use in that they act as spirit levels and inform us (unconsciously, however) when we are about to fall over. They, too, are filled with a liquid, and their walls contain cells with hair like projections. In these cells end certain fibers of the auditory nerve. When the body or the head is moved in any direction, the liquid moves in one or the other of the canals. Of course, in the daytime a person can see with his eyes what position he is in, or he can see when he is about to fall over; but with the semicircular canals he feels it much more quickly, and by reflex action he rights himself at once.

SUMMARY

The stimuli from the outside that cause us to hear are waves or vibrations of air. These are collected by the outer ear and directed to the ear-drum, which is thus made to vibrate. The sound waves are carried across the middle ear by a series of three bones, the inner one of which, the stirrup, knocks against the opening of the inner ear. It is in the cochlea of the inner ear that the auditory nerve reaches the end cells that catch up the waves of sound. These cells are upon the partition of the spiral canal which winds up through the cochlea. The wave travels in the liquid with which the cochlea is filled to the top of the cochlea on one side of the partition and comes back on the other side. As it travels through the cochlea, it stimulates the end cells to which the auditory nerve fibers are attached. The impulse is carried to the brain, and thus we hear.

The semicircular canals also contain a liquid and end cells with nerve fibers. The canals are so placed that whenever we change our position the liquid in one or the other of them moves. The canals thus help us to maintain the balance or equilibrium of the body.

QUESTIONS

1. What is air composed of (Chapter XXXI)? 2. How are sound waves produced? 3. Name the divisions of the ear. 4. Name the parts of the outer ear and tell the function of each part. 5. What separates the outer ear from the middle ear? 6. How may the ear-drum be injured? 7. How is it protected? 8. How does the middle ear communicate with the outside air? 9. Why

is this so? 10. How do sound waves cross the middle ear? 11. How may diseases of the nose and throat cause diseases of the middle ear? 12. Name the two parts of the inner ear. Which of these is used in hearing? 13. Where are the end cells of hearing? 14. How do the sound waves reach these cells? 15. How are impulses carried from these cells to the brain? 16. What is the use of the semicircular canals?

CHAPTER LV. SIGHT

As the ears are the organs of hearing, the eyes are the organs of sight. As the ears are constructed to receive stimulations of sound waves and start these stimulations to the cerebrum, so the eyes are built to receive from *light waves* stimulations that are passed on to nerves going to the cerebrum.

Sound waves are vibrations of air, and without air there could be no sound. But light travels far beyond the limit of the atmosphere, for it comes to us from the sun, moon,

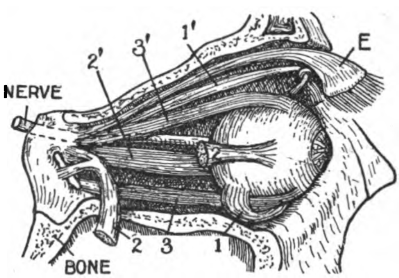


Figure 220. — The muscles that move the eyeball.

and stars. Air seems to us to be very light and thin, but it is really very heavy and dense when compared with the substance that carries light. This substance is called *ether*. It pervades all space, and waves of ether are light waves. Although we cannot see the waves of ether, we must imagine them to be like the waves rippling across the surface of a pond of water. The eye has end cells, sensitive to these delicate waves of ether, and branches of the nerve of sight (*the optic nerve*) to carry the impulse to the brain.

Protection of the Eye. The eye cannot be put away inside the bones like parts of the ear, but it, too, is protected. It is set back in an orbit or hollow of the skull (Fig. 167), so that a fall or a blow on the face will not be very likely to injure the eye. Again, two flaps of muscle, the *eyelids*, can be pulled over the eye to protect it against objects flying toward the face. (Study the action of the eyelids from the standpoint of reflex action.) The eyelids are aided in their work of keeping out dust and dirt by protruding hairs on their edges, the *eyelashes*.

The Tear Glands. You have noticed that persons and animals wink at intervals. The purpose of this is to distribute over the eyeball a fluid secreted by the tear glands, for the surface of the eyeball must be kept moist. The

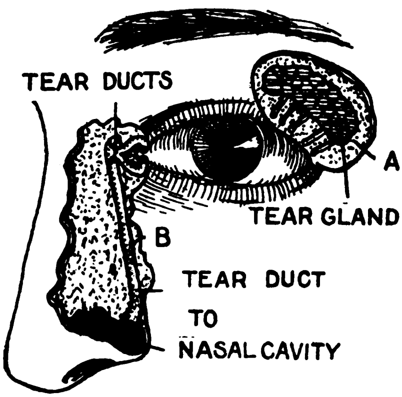


Figure 221. — The tear gland of the eye.

tear glands lie along the outer side of the eye, and the tear is emptied on the under side of the upper eyelid (Fig. 221). The tear is usually carried off by certain tear ducts that lead to the nose; when one weeps the glands form tears faster than the ducts can carry them away.

The secretion of the tear glands is regulated by nerve fibers from the cranial nerves and, as you would expect, from the sympathetic system. One of the two openings of the tear duct can be seen in the center of a little elevation or papilla on the edge of the lower eyelid, near the inner corner of the eye. That the tears do not always run over the edge of the eyelid is due to the fact that there is a row of *oil glands* which empty their fatty secretion on the edge of the lid, thus preventing the tears from running over. In certain diseases these glands secrete too large a quantity of oil, which on drying becomes hard and yellow. When this happens during sleep, it is often difficult to open the eyes on awaking.

OBSERVATION AND PRACTISE WORK. Using a mirror, find the papilla on the lower eyelid as described above. Pull the eyelid down a little and the papilla with the opening to the tear-duct will come to view. Make a drawing of the eye, with the eyebrows, lids, eyelashes, and other parts. Name them in the drawing.

How the Eyeballs are Moved. Looking at a sheet of paper, you will notice that, without turning the head, you

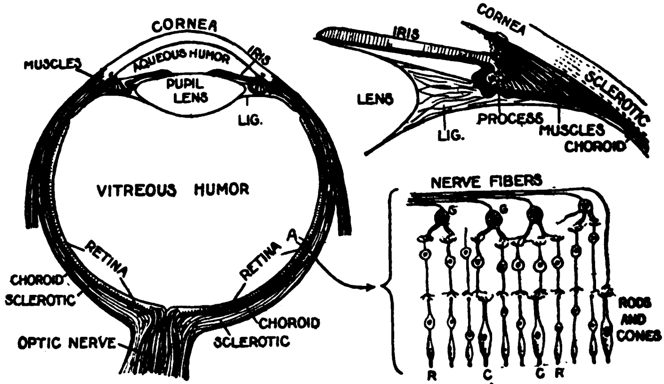
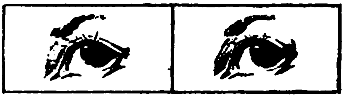


Figure 222. — Section of the eyeball with parts named.
Figure 223. — A part of Figure 222 enlarged, to show attachment of lens.
Figure 224. — The part *A* of the retina in Figure 222, much enlarged to show the seeing cells of the retina.

can glance from the center to the right and left edges, to the top and bottom edges, and to the corners of the paper. It takes six muscles (three pairs, Fig. 220) to move each eye, and it takes three pairs of cranial nerves to govern these muscles and to regulate their action. The two eyes move together, since the motor nerves send branches to corresponding muscles of each eye.

The Form and Inner Structure of the Eyeball. The eyeball is almost spherical in shape, bulging a little in front, as shown in Figure 222. The wall of the eyeball has three coats: the outer or sclerotic coat, the middle or choroid coat, and the inner or retina.

The white of the eye is a part of the sclerotic, as is also the transparent *cornea*, through which the black pupil and the colored *iris* can be seen. The choroid contains dark pigment or coloring matter so as to darken the inside of the eye; for the eye is a miniature camera, a dark box with only a small opening in front for the light to enter. This opening is the *pupil*, which is surrounded by a colored ring, the iris, a part of the choroid coat. A person's eye is said to be blue or brown if the iris is blue or brown. In bright light the pupil is small (Fig. 226); in the dark the pupil is large (Fig. 225). There are smooth muscles in the iris that regulate the size of the pupil, and these muscles are regulated by cranial and sympathetic nerves. Their action is reflex and involuntary, as described in Chapter XLIV.



Figures 225 and 226. — The pupils of the eye, large and small.

Observation Work. Repeat the experiment on the reflex action of the iris muscles.

The Lens. Immediately behind the iris is the lens. This is a most important organ; it enables us to see clearly and is to the eye what the glass lens is to the camera. The eyeball is filled with a clear, watery fluid, the *aqueous* *humor* (Fig. 222) in front of the iris, and with a clear, jelly-like mass, the *vitreous humor*, behind the lens.

The Retina. Waves of light enter the pupil, pass through the lens, and are distributed over the inside wall of the eye. Where, then, are the sensitive cells and their nerve fibers, that catch up the light waves? These cells are found in the coat of the eye called the *retina*, inside of the choroid layer (Fig. 222). This layer of sensitive cells occupies a position similar to that of the sensitive film or plate in a camera. The retina is, therefore, the sensitive coat of the eye.

Figure 224 represents a section of the retina, much enlarged. The sensitive cells are *rods and cones* (so called from their shape) and stand pointing toward the choroid layer. More or less closely connected with these are nerve fibers from the optic nerve. Light waves strike the rods and cones and cause nerve impulses in the fibers of the optic nerve. These, on reaching the nerve cells of the cerebrum, cause the sensation of sight.

SUMMARY

The eye, or seeing organ of the body, may be likened to a camera. Like the camera, the eye is a dark box, the choroid coat serving the purpose of the black paint on the inside of the camera. There is an opening, the pupil of the eye, to admit the light. The size of this, and consequently the intensity of the light entering the eye, is regulated by the iris. The sensitive film is the retina, containing the rods and cones, which are the sensitive end cells, or seeing cells, connected with fibers of the optic nerve. These end cells are sensitive to waves of ether, called light waves. There is, too, a clear convex lens, which serves the eye in a manner to be described in the next chapter.

QUESTIONS

1. What are sound waves? Light waves? 2. Why cannot the eye be put away in the skull bones as is the inner ear? 3. How is

the eye protected against blows? Against dust? Against drying? 4. How are tears ordinarily kept from flowing over the edge of the eyelids? 5. Point to your own tear glands. 6. Why do we have to blow the nose when we begin to cry? 7. How many muscles move the eyeball? 8. How many nerves are represented in Figure 202 as passing to the eyeball? 9. From a section drawn on the blackboard after Figure 222, point out the three coats of the eye. 10. What is the function of each coat? 11. Of what part of Figure 222 is Figure 224 an enlargement? 12. How does the pupil grow larger and smaller? 13. Why does it change in size? 14. Why cannot owls see well in daylight? 15. Where is the cornea? The lens? The iris?

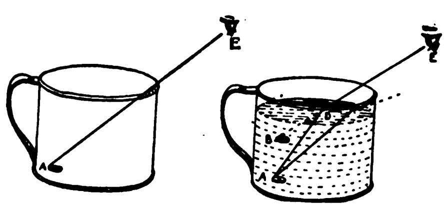
CHAPTER LVI. HOW WE SEE

In the last chapter we learned the parts of the eye and described where the cells sensitive to light waves are situated. In this chapter we shall learn how we see *clearly;* that is, how the rays of light are made to fall upon the cells of the retina in the right way.

The Refraction of Light. Rays of light tend to travel in a straight line. But when, after passing through air, they strike the surface of water or glass or the transparent parts of the eye, the rays are bent suddenly out of their course. We say they are broken or refracted. This refraction can be illustrated by the following experiments:

Figure 227. — A pencil looks bent or broken when immersed in water.

Experiments on Refraction. (1) Put a pencil in a tumbler of water and note that the pencil looks broken, as shown in Figure 227. (2) Place a coin in a tin cup and have ready a quantity of clear water. Stand so that the eye is in the position shown in Figure 228 and the coin is just out of view. Now pour water into the cup gently. Note that the coin gradually comes into view as the water level rises. Figure 229 gives the explanation of this. Rays of light between the bottom of the cup and the eye (*E*) are refracted



Figures 228 and 229. — An experiment in refraction. (See text.)

at the surface of the water where water and air meet. Therefore the coin is in full view, although not in direct line, and seems to be raised above the bottom of the cup, as at *D*. (3) To show how a lens refracts the rays of light, hold a glass, a magnifying glass or a convex lens from a pair of spectacles, in the sun, using it as a burning glass. The rays of sunshine are refracted by the lens and turned together to a *focus*, or central point.

How the Image Is Thrown upon the Retina. The rods and cones that catch up the rays of light are very small. In order to see sharply and clearly, a single rod or cone

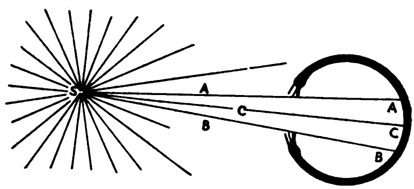


Figure 230. — The rays of light from a single point would be scattered over the retina if there were no cornea or lens.

must receive the light from a single point of an object. To make it clear how an image is formed on the retina, we may begin with a simple thing, for instance a small spark the size of the period used in punctuation. The spark gives off rays of light in every direction, for it can be seen from all sides. But only those rays which pass through the pupil

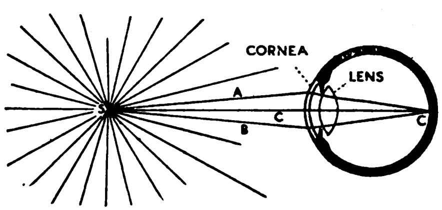


Figure 231. — The cornea and the lens focus rays of light.

would reach the retina. Thus, of all the rays of light represented in Figure 230 which radiate from the spark, (*S*), only *A*, *B*, and *C* reach the retina. Now, if the light rays would enter the eye unobstructed, as represented in

Figure 230, the rays *A*, *B*, and *C* would strike the retina at *a*, *b*, and *c*. So with all other rays between them. There would be so many images that we should see the spark as a large, round spot. Of course, if the pupil were so small that only ray *C* could enter, there would be but one image, *c;* but this would not be bright and strong. It is, therefore, desirable that all the rays that strike the eye in front of the pupil (*A*, *B*, and *C*) should fall on the point *c*, as in Figure 231. This is brought about by the convex surfaces of the cornea and the lens, which refract the rays and turn them together to a point or focus on the retina (*c*, Fig. 231). Collecting the rays of light and bringing them to a focus is called *focusing*.

So it is with all the many rays of light that pass out from every object. In Figure 232 the rays from the point *A*,

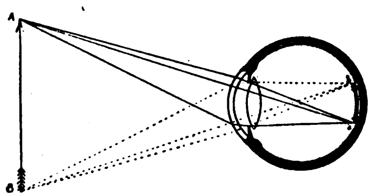


Figure 232. — Fvery ray of light from any one point of an object is focused on the retina. This causes a clear image of the object to form on the rods and cones of the retina. Two points, *A* and *B*, are taken as examples.

on the head of the arrow, are focused on point *a* of the retina; those from point *B*, on the feather of the arrow, are focused at *b* on the retina. Each part of the arrow is thus clearly cut on the retina. The images of objects are thrown on the retina inverted. In order, then, that the image of the object may be clear, the cornea, the lens, and the entire eyeball must be of the right shape. Such is the case in the normal eye.

Observation Work. Look out of the window into the distance. Now hold up your hand in front of your face and continue looking into the distance between the fingers. The hand is not seen clearly; it is blurred. Again, hold your finger one foot from your face, between your eyes and the landscape. Look at your finger. If you see the finger in clear outline, the objects of the landscape are blurred. This is due to the action of muscles changing the shape of the lens, as will be noted below.

Accommodation. As shown in the experiment just made, there must be something in the eye which must be set for seeing far or near. That something is the lens, which accommodates the eye for far or near sight. For seeing near objects, the lens must bulge out in front; that is, it must be more convex. It is made so by muscular

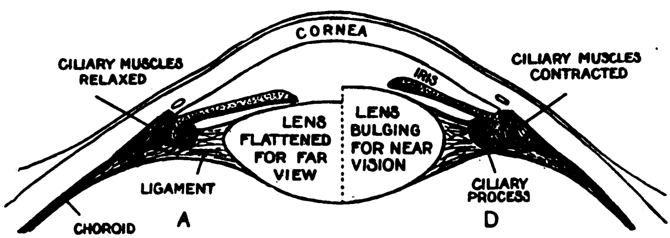


Figure 233. — Diagram to show how the lens is changed for far or near vision. (Compare with Fig. 222.)

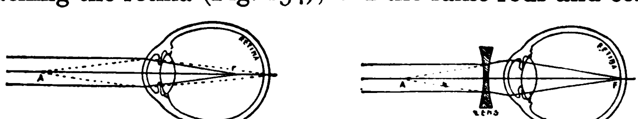
effort. Figure 233, which is part of Figure 222 enlarged, shows that the lens is attached by a ligament (*Lig*) to a process called a *ciliary process* in the wall of the eyeball. The ligament is a complete circle of ciliary processes. Muscles called *ciliary muscles*, are so attached that when they contract, the ciliary processes are pulled toward the lens and the ligament holding the lens slackens. The result is that the lens, being elastic, assumes a more convex form (*B*, Fig. 233). The lens is not stretched and flattened by muscular effort, as is sometimes thought, but is made to bulge or thicken. When the ciliary muscles relax, the ligament of the lens resumes its pull and the lens again takes on the flatter shape for seeing at a distance. It is important to note that it requires muscular effort for seeing close by, as for example in reading and sewing. Study carefully *A* and *B*, Figure 233.

Experiment. To feel that muscular effort is needed for near vision, look into the distance. The lenses of your eye are now accommodated for far vision. The ciliary muscles are at rest. Now bring the finger up rather closely before the eyes and remove the attention from the distance to the finger, noting carefully the feeling in the eyeball as the accommodation to near vision is being made.

The Normal Eye. In a normal eye the eyeball is of the right shape; the iris properly regulates the amount of light that enters the eye; all the parts through which light has to pass are transparent (name them); the lens and cornea have a smooth, regular surface, without irregularities; the lens is elastic, responding readily to the effect of the ciliary muscles, or springing back into the resting position; and the ciliary muscles act perfectly in accommodation for far and near vision.

The Defective Eye. Common imperfections in vision are due to defects in regard to one or more of the points just enumerated. The image must come to a focus *exactly on the retina* (Fig. 232), or the image will not be distinct.

In *near-sightedness* the image comes to a focus before reaching the retina (Fig. 234), and the same rods and cones

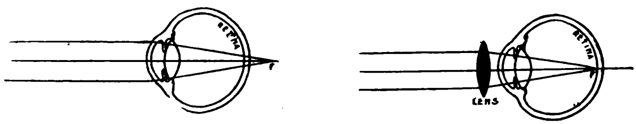


Figures 234 and 235. — In short-sightedness the eyeball is too long. This may be corrected by glasses with concave lenses.

receive rays of light from different parts of the object, thus confusing the image and making it dim and blurred.

Such an eye would be helped by spectacles with concave lenses, for such lenses would spread the rays of light and prevent their coming to a focus too soon (Fig. 235). Near-sightedness is usually due to the fact that the eye is too deep; that is, the distance from cornea to retina is too great (Fig. 234).

Far-sightedness is due to the opposite cause from that of near-sightedness; the eye is too short from cornea to



Figures 236 and 237. — In far-sightedness the eyeball is too short. This defect is corrected by wearing glasses with convex lenses.

retina (Fig. 236). In such an eye the image reaches the retina before the rays of light have been brought to a focus. A person suffering with far-sightedness should wear glasses with convex lenses, for these bring the rays of light together and help the lens of the eye to focus the rays on the retina (Fig. 237). Many headaches are due to imperfect eyesight that might easily be corrected with glasses or spectacles.[1]

Astigmatism is a defect of the cornea or the lens, in which either or both have irregularities or uneven places in their curved surfaces. This is a common cause of imperfect vision with children, and should receive prompt attention. A pupil poor in reading, but good in other studies, probably has something wrong with the eyes.

SUMMARY

Rays of light tend to travel in a straight line. When they pass from the air into a denser medium, as water or the cornea or the lens of the eye, the rays are broken or refracted. In

[1] Most old persons are far-sighted. The tissues of the lens become hardened and cannot be accommodated for near vision. This is the reason why most old persons can use one another's glasses.

the normal eye all rays of light are thus made to fall upon the right places on the retina, so that we see clearly and sharply.

For far and for near vision a different focus is required. This change of focus is brought about by a change in the convexity of the lens. When the ciliary muscles contract, they bring the ciliary processes nearer the lens, thus allowing the elastic lens to bulge out. When the muscles relax, the lens is brought back to the flatter shape. We can rest the eye from continued close work by occasionally looking off into the distance. Short-sightedness, far-sightedness, and astigmatism are common defects in vision, due mainly to the imperfection of the focusing apparatus of the eye. They may be corrected by wearing the glasses with the right kind of lenses.

QUESTIONS

1. Why can we not see all the rays of light coming from a given point? 2. What is meant by refraction? 3. Describe two experiments to illustrate refraction. 4. How is the lens held in place? 5. Describe focusing. 6. Why do rays of light have to be focused on the retina? 7. How are they focused? 8. How is the eye accommodated for seeing near objects? 9. Draw Figure 222 on the board and explain the use of all the parts shown. 10. How can you prove that it requires muscular effort to accommodate the eye for seeing a near object? 11. How can you rest your eyes at intervals when engaged in close work? 12. Mention the common defects of the eye. 13. Describe the near-sighted eye. The far-sighted eye. 14. Why do people usually become far-sighted with age? 15. What is astigmatism? 16. What can we do for these common optical defects?

CHAPTER LVII. HYGIENE OF THE EYES

A study of the anatomy of the eye and the physiology of its parts enables us to study intelligently the hygiene of the eye.

Rest. Since the ciliary muscles contract to accommodate the lens for near work, such as reading or sewing, it is necessary that they be rested from time to time. This is, of course, easy to do by simply looking into the distance. This relaxes the muscles and has the same effect on them as relaxation has on the muscles of the arms and legs.

Rest is necessary for the optic nerve as well as for the muscle of the eye. Overworking the nerve of sight not only affects this nerve, but often causes inflammation of the eyes, which can best be cured by rest.

The Size of Type. The size of type used in printing the matter you read is an important consideration. If the type is too small, the strain on the eyes is very great. It does not pay to buy a cheap book with poor type. The size of the letters in the Primer and First Reader used in your school is probably the best size for a beginner. This book is printed in clear type of the right size for most people.

Direction of the Light. The best rule to follow is to have the light pass *over the left shoulder* on to the printed page. *The light should never come from the front.* In a school room, the front windows, if there are any thus wrongly placed, should be darkened. The main light should come from the left. The windows should be placed high, even touching the ceiling, for it is the light *from above* falling *on* the desks which is best in the school room.

When reading by artificial light, do not allow the light to shine directly into the eyes. It is well to shade the light or to place a shade over the eyes to protect them.

Intensity of Light. For reading, or other close work with the eyes, the light should be neither dim nor very bright. If too dim the pupil of the eye becomes so large as to cause the letters of the printed page to be less clear and distinct. It is a great mistake to read at dusk without artificial light.

If window shades are needed to keep out the direct rays of the sun, they should be of the adjustable kind, so as to allow some light to enter from the top if possible. Window shades that pull up from the bottom are often more advantageous than those that pull down from the top. Shades pulled down on a sunny day should be raised on a cloudy day.

Steady Light. A flickering light, such as that of a candle, or a simple gas jet without a mantle, is hard on the eyes. Reading on trains should also be avoided.

Eye Strain. The eyes are strained in various ways even when not worked excessively. The strain is usually due to defects in particular parts of the eye or eyes. In the far-sighted eye, the ciliary muscles are under the greatest possible strain when close work is attempted. Astigmatism is a source of much worry and causes great strain. Sometimes the muscles that move the eyeball do not move in orderly fashion, so that focusing both eyes on a given object becomes difficult. All these defects cause eye strain, which usually becomes more and more serious the longer the eyes are neglected. Such strain affects not only the eyes, but in time causes sick headaches, nervousness, and even indigestion. Many children, otherwise bright and capable, are backward in school for no other reason than that their eyesight is defective.

Spectacles. All these defects in vision may be greatly relieved, and often permanently cured, by the fitting and wearing of proper glasses or spectacles. One should, of course, be careful to have the eyes fitted by a trained oculist, as wrong glasses do more harm than good. Teachers should be on the lookout for cases of defective eyesight, and parents should consult a competent oculist concerning the child's eyes when there is the slightest suspicion of anything wrong with them.

Cinders in the Eye. The eyeball is covered, and the eyelids are lined, with a very delicate membrane. The presence of hard, sharp particles, such as cinders or sand grains, irritates this membrane and causes inflammation of the eyeball and of the lid. The foreign particles should be removed with the corner of a clean pocket handkerchief. Disease germs are also likely to enter the eye and cause inflammation. The eye should not be rubbed with the fingers, as by this means germs are often transferred to the eyes.

Trachoma. The disease called *granulated lids* (properly called *trachoma*) is the worst communicable disease that affects the eyes. It is not very common in this state, and yet it is fairly well distributed over the different counties. It causes sore eyes, and later scarring under the lids, so that they pucker up and do not fit the eyeball. The cause of trachoma is not known, but we do know positively that it is contagious. It is communicated by the matter or secretion from the eyes of persons suffering with the disease.

The secretion in some way or other gets into the eyes of the new victim. The disease may be spread by public towels or by pencils borrowed from children who have sore eyes. Gnats and flies are also responsible for the spread of the disease. These insects light on the eyes of one person, pick up a drop of the infected fluid, and carry it to the eyes of another. For this reason, as well as for many others, our houses should be screened to keep out insects.

Sore Eyes. The ordinary sore eyes is another contagious disease which is called *pink eye*. This is carried from one child to another in the same way as trachoma. In 1902 there occurred in Texas an epidemic of this disease, due to the gnats and flies. We do not often have so many insects as we had in 1902, but we have the public towel with us at all times, and we should be on our guard against that. A good substitute for it is the sanitary paper towel, which can be bought at about a quarter of a cent apiece (Fig. 29).

A very dangerous eye disease sometimes affects young infants. If not treated at once, the child will become quickly and permanently blind.

Sore eyes are also caused by eye strain, by smoking, and by other causes easily avoided.

SUMMARY

On account of the great usefulness of the eyes and their delicacy, we should take the utmost care of them.

The eyes may be spared in many ways. They should not be overworked. Both the ciliary muscles of the eye and the optic nerve should be given sufficient rest. We should always be careful about the size of type of the books and papers that we read and of the character and direction of the light.

The light should be steady and of the right strength. We should avoid reading in dim light and, by using the right kind of shades, should keep out strong light. Light should never come from the front, nor should it shine directly into the eyes.

The membrane covering the eye is easily injured by foreign particles. These should be removed with great care. The eyes should never be rubbed. Disease germs often attack the eyes. Among the common contagious diseases of the eye are trachoma, sore eyes of infants, and pink eye. These diseases may be spread by towels, gnats, and in other ways and may be avoided by appropriate means. Sore eyes of any kind should receive prompt treatment.

QUESTIONS

1. Why is the care of the eyes important? 2. How may you rest the ciliary muscles during reading? 3. Discuss the size of type for reading. 4. What is the best and what the worst direction for the light to come into a school room? 5. How can we regulate the intensity of light? 6. Make five suggestions for the hygiene of the eyes at home. 7. Tell why you think that the wearing of glasses is not a mere fad. 8. How should a cinder be removed from the eye? 9. Name several germ diseases of the eye. 10. How are these diseases scattered and how may they be avoided? 11. Find out what the state law requires as to the lighting of school houses.

CHAPTER LVIII. ACCIDENTS AND EMERGENCIES

When persons are accidentally injured, a physician should be called immediately. The following paragraphs are to teach what should be done while the physician is on the way.

Examination of the Injured Person. The first thing to do when any one is injured is to look him over and see whether he is losing blood and whether he is getting his breath. If he is not bleeding very much, and is breathing, we may rest assured that there is no pressing need for immediate action.

Severe Hemorrhage or bleeding. If, however, the injured person is bleeding profusely, something must be done at once. In case of a severe hemorrhage, that is, if the patient is bleeding as much as a teacupful every minute or two, it is absolutely necessary to stop the hemorrhage at once. There is no time to hunt up medicines or clean bandages. In these circumstances the cleanest cloth that can be found must be pressed into and around the wound. If it is pressed tightly, with all one's strength, it will stanch almost any hemorrhage.

After the bleeding is hurriedly stopped, or at least diminished in this way, it is time to look around for some more satisfactory method of preventing bleeding till assistance can arrive. Sometimes it is necessary to hold the fingers pressed into a wound for an hour till the surgeon can reach the patient. If the hemorrhage is from an extremity, — that is, from an arm or leg, — a tight bandage, which can be made with a handkerchief, wrapped around the limb between the wound and the heart, will stop the bleeding. A tight bandage should not be left on a limb for more than half an hour or it may cause *gangrene*, which will result in death and putrefaction of the limb.

A slight hemorrhage should be stopped by placing a clean white cloth over the wound and making gentle pressure. Usually, binding the cloth on to the wound will prevent a return of the hemorrhage.

Cuts and Other Open Wounds. These should not be washed with water unless the water is pure. Boiled water is always free from germs. A reliable antiseptic or disinfectant should be applied to wounds of this character, and they should be covered with clean white cloths, preferably cloths that have been boiled and dried without being handled. Disinfectants have been described in Chapter XIX. It is never wise to employ a solution of carbolic acid as a permanent dressing. Gangrene has been produced in numerous instances by dressing wounds in moist carbolic bandages.

Fracture of Bones. Broken bones may in certain cases be dangerous. The worst thing that can happen after a

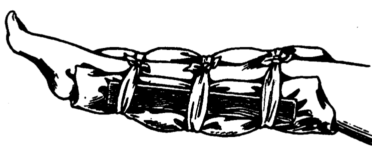


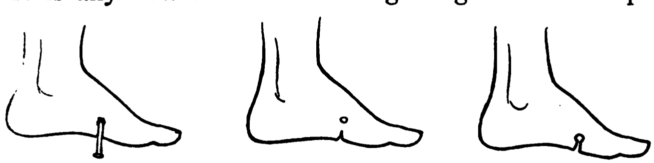
Figure 238. — A pillow and two boards make a good temporary brace or splint for a broken limb. The pillow is made into a trough, the limb is placed in this trough, and the boards are adjusted and held in place by several bandages.

fracture has occurred is for the bones to protrude or stick out through the skin. When they do so, they are likely to become infected by germs, especially the tetanus or lockjaw germ. The bones should therefore be handled carefully to avoid pushing them through the skin. The picture shows a pillow-splint that can be applied when no surgeon is at hand. This splint is suitable for fracture of arm or leg.

Tetanus or Lockjaw. The tetanus, or lockjaw, germ is one of the worst germ enemies we have. This germ more frequently lives outside the body than inside. It is not like the typhoid germ, which multiplies only in the human body. The tetanus germ lives in the ground, especially around gardens and horse lots. It practically never harms the human body except when introduced through an open wound. So far as we know, swallowing the tetanus germ never hurts any one. *The tetanus germ cannot live in the air; it has to be shut off from the air.* Supposing that a wound has been made by a rusty nail, after the skin swells a little and closes the hole made by the nail, the germ is down under the skin and is shut off from the air. You have noticed that healing of the skin often occurs, even though there are germs and pus deep down under it.

Tetanus is Almost Incurable. After this disease once develops, the doctors have great difficulty in healing or curing it. Lockjaw causes terrible spasms all over the body. The locked jaws are the least part of the disease. *If we are to save one's life after he has thrust a nail into his foot, we must act before the disease develops.*

Usually tetanus develops about a week or ten days after the wound is received. The proper treatment is to open up the wound and let the air get down into the depths of it. This is shown in Figures 239–241. If there is any doubt about the air getting into the deepest



Figures 239–241. — A lockjaw wound: Figure 239, a nail thrust; Figure 240, the lockjaw germs are shut off from the air when the skin over the wound heals. The only safe thing to do is to open the abscess and let in the air (Fig. 241).

part of the wound, tetanus antitoxin should be given. If these precautions are neglected, and if tetanus once appears, all the powers on earth cannot with any certainty prevent death. Over three fourths of all cases of tetanus die. The antitoxin is good for prevention, but cannot be relied upon to cure after the disease once develops.

Narrow and Deep Wounds. All narrow, deep wounds are especially dangerous, because the skin closes up and shuts out the air, making it possible for the tetanus bacterium to live. The burns made by powder from little toy pistols and from firecrackers are deep wounds, and often cause lockjaw. These wounds should be carefully treated at once, or it will be too late. Splinters also make narrow, deep wounds and are likely to cause lockjaw.

Snake-bites. The number of deaths occurring in Texas from snake-bites is very small. In case one is bitten by a snake, unless he knows that the bite was inflicted by a harmless variety, it is well to proceed as follows: If the wound is on a leg or an arm, as is likely, quickly wind a bandage that can be twisted tight around the limb between the wound and the heart. A handkerchief serves well for a bandage; out in the woods, twigs of some tough plant will do. After bandaging, to prevent the blood from carrying the poison toward the heart, take a knife and sterilize the blade of it by heating it in the flame of a match. Then make an incision over the wound made by the fangs of the snake, cutting two cross marks each a quarter of an inch deep. If available, crystals of permanganate of potash may be rubbed on the open cut. Squeeze out as much blood as possible up to the amount of a wineglassful, but no more.

You can always tell whether your treatment is effective or not, for if ineffective the patient will become weak and pale in less than half an hour. Mere fainting, which lasts only a few minutes, is not to be mistaken for this. A teaspoonful of spirits of camphor in half a teacupful of water may be given to prevent fainting. The tight bandage need not be kept on longer than thirty minutes in case no symptoms of weakness arise; but if they do, and the bandage is kept on longer, it should be removed for one minute every twenty minutes.

A word of caution is here needed about the use of alcohol. Whisky should not be used in case of snake-bite. The medicine to take along for snake-bites, when on hunting and camping trips, is potassium permanganate. A strong solution of this in water is to be poured into the crossed incision described above.

There are only a few poisonous snakes in Texas. The worst and most common are: the rattlesnake, which is familiar to most people the world over; the copperhead, which is a dull-mottled snake, with a blunt tail, and is found in dry upland fields; and the cotton-mouth moccasin, which has a blunt tail, is white under the chin, and lives in streams and ponds. The prairie runner or "coachwhip," the chicken snake, and the garter snake are harmless.

Fainting. There are few accidents that excite the bystander more than fainting. When the fainting person falls, let him lie, but see to it that he has plenty of fresh air. Fanning the person is helpful, as is also the inhalation of a little ammonia. A dash of cold water in the face is also good. Recovery from a fainting spell usually takes place in a few minutes.

Burns. Women and girls are especially in danger of getting burned because of their loose clothing, and also because of their duties in the house and around the fire. In 1911 there were thirty-nine women accidentally burned to death in Texas.

Burning is a form of accident for which very little can be done before the physician arrives. Clean cloths greased with olive oil, linseed oil, or petroleum jelly may be laid over the burned surface. It is well to keep unclean articles from touching the raw surfaces of the burn. It is not well to put water on large burns. The dead skin should be left in place until the doctor comes.

Common Causes of Burns. Burns are usually, though not always, the result of carelessness or ignorance with regard to the nature of coal-oil or kerosene. *Never start a fire with kerosene oil.* The oil so easily bursts into flame that the slightest spark is sufficient to cause it to do so.

Furthermore, when oil once starts to burn in an open place, it burns with such violence as to spatter burning particles all around.

Smothering Flames. Every one knows that when flames are fanned they burn more strongly. Therefore, when a person has caught fire, he or she should be prevented from running wildly about. If there is not enough water at hand, the flames may be smothered by throwing the burning person to the ground and piling on him rugs, blankets, and similar articles that may be handy.

Artificial Respiration. This means making a person breathe when for any cause his natural breathing movements have stopped, as for instance when one has been

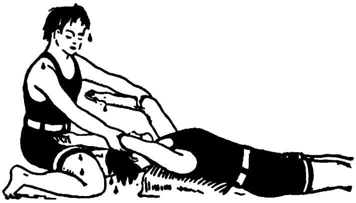


Figure 242. — First position in giving artificial respiration.
Figure 243. — Second position in giving artificial respiration.

shocked badly by electricity or has been almost drowned. The best method of causing artificial respiration may be used by one person alone, and is illustrated in Figures 242 and 243. The injured person is placed face down, with his head turned slightly to one side to keep the mouth out of the dirt. If possible, the head should be turned downhill. The person who gives this artificial respiration sits across the hips of the injured one, as shown in the picture, and places his hands on the other's back and lower ribs. By alternately pressing and releasing pressure with the hands, fifteen times to the minute, air is first pressed out and then drawn into the lungs. This method of artificial respiration is especially good for the reason that the patient is lying on his face and the tongue does not fall back and stop up the throat. In the older methods two persons were required, because the patient was on his back and his tongue had to be held forward by a second person. The movements in artificial respiration should never be forcible enough to injure the lungs, and as soon as the patient shows signs of gasping, an attempt should be made to cause exhalation when he is trying to exhale. It would, of course, be unwise to exert pressure on his chest if he were trying to inhale.

IMPORTANT POINTS

If the injured one is breathing, and if he is not bleeding, there will not be any need for very special haste.

If he is bleeding very rapidly, anything clean pressed into and around the wound will stop the bleeding till you can do something further.

Do not wash cuts with water unless the water has been boiled, and do not touch the cut with anything except a clean cloth.

Nail thrusts are dangerous and should be opened up thoroughly to let in air and prevent the growth of the tetanus or lockjaw germ.

To avoid burns, do not take kerosene, gasoline, naphtha, or alcohol near a stove; do not pour oil into a warm stove; and do not try to fill a lamp or oil stove while it is lighted.

To put out clothing that has caught fire, throw the burning person to the ground and smother the flames with a wet or dry blanket, rug, carpet, or other cloth.

QUESTIONS

1. When is bleeding dangerous? 2. What is one sure way to stop bleeding? 3. Why is it unwise to wash a fresh cut? 4. Give two common causes of burns. 5. What accidents are likely to produce lockjaw? 6. Out on a ranch, what would you do if a friend were bitten by a large rattlesnake? 7. Would you prop up a person who has fainted, or let him lie horizontally? 8. How do you give artificial respiration?

APPENDIX A. POISONING

When a person has taken poison, there are certain general rules to follow, whether the nature of the poison be known or not. These general rules are given below, together with special reference to the commoner poisons.

For Faintness. If the patient seems faint, let him lie down; then give him stimulants, such as a cup or two of strong coffee, a teaspoonful of aromatic spirits of ammonia, or a teaspoonful of Hoffman's anodyne.

For Sleepiness. If a patient seems sleepy, keep him awake by bathing his face with cold water and fanning him, but do not wear him out by walking him around.

For Coldness of Hands and Feet. If the extremities are cold, warm them with hot-water bottles, warm bricks, or warm flatirons.

To Produce Vomiting. A tablespoonful of mustard in a pint of warm water is immediately effective. Warm, salt water in large quantities is also good. The stomach tube is good in the hands of a physician or nurse.

To Counteract Acids. If an acid has been swallowed (carbolic acid is not here included), alkaline substances should be given, such as cooking soda, prepared chalk, whiting, magnesia, and limewater. Follow with raw eggs or olive oil.

To Counteract Alkalies. If a strong alkali has been taken, such as concentrated lye, acids such as vinegar or lemon juice should be given. Follow with raw eggs or olive oil.

Carbolic Acid Poisoning. This must be treated within twenty minutes or death may result. The treatment is undiluted whisky, or pure grain alcohol diluted half and half with water. If this is not at hand, Epsom salts in the usual doses is almost as good. If the alcohol is used, Epsom salts should be used a little later.

For Arsenic Poisoning. Poisoning from "Rough on Rats" or other forms of arsenic should be treated by remedies to cause vomiting as described above. These should be followed or accompanied by raw eggs or cooked starch paste. The druggists prepare a regular antidote to arsenic, which should be given as soon as it can be obtained.

For Phosphorus Poisoning. Phosphorus poisoning should be treated by remedies to cause vomiting, and by stimulants and raw eggs. *No oil should be given under any circumstances.*

For Opium Poisoning. Morphin, paregoric, laudanum, and other forms of opium all act alike, and should be treated by remedies which cause vomiting, by tannic acid, one teaspoonful, or by potassium permanganate, five grains repeated in ten minutes. In addition, the patient should be kept awake by strong coffee, cold water, and attempts at rousing.

To Avoid Poisoning. Medicines and poisons should be kept out of the reach of children and medicine should never be given in the dark. When concentrated lye is used in scrubbing the floor, the open can should never be left on the floor or in reach of children.

Figure 244. — Medicines and poisons should be locked up out of reach of children.

APPENDIX B. ABSTRACT OF THE SANITARY CODE FOR TEXAS

Note. — The Sanitary Code for Texas is important; it not only has a bearing on the everyday life of each citizen, in that it must be obeyed, but it also has great educational value, for it expresses the judgment of Texas sanitarians and legislators as to the wisest method of combating preventable disease. There are many valuable rules in the Sanitary Code which are not familiar to the citizens; some of these rules need to be invoked in time of epidemic, but others should be enforced every day to protect the public against such common dangers as tuberculosis and typhoid fever, which in Texas, as elsewhere, are prevalent at all times. Again, some of the rules of the Code relate to schools. These have been printed in black-faced type, and will be of service to teachers and trustees.

RULE 1. Any physician in Texas who is called in to treat a person sick with any contagious disease is required to notify immediately the local health authority.

RULE 2. By "local health authority" is meant the city or county health officer or the local board of health.

RULE 3. The following are considered as contagious diseases: Asiatic cholera, bubonic plague, typhus fever, yellow fever, leprosy, smallpox, scarlet fever (scarlatina), diphtheria (membranous croup), epidemic cerebrospinal meningitis, dengue, typhoid fever, epidemic dysentery, trachoma, tuberculosis, and anthrax.

RULE 4. The local health officer is required to keep a record of all contagious diseases reported to him, and to make a monthly report of these cases to the State Board of Health. The records of tuberculosis are to be kept private.

RULE 5. School trustees and health authorities are required to regulate their quarantine in a certain way, as follows:

a. Absolute quarantine contemplates that no persons shall enter or leave the premises, guards being used to enforce this rule if necessary; the premises shall be placarded; no articles shall be allowed to pass out of the premises; food shall be furnished by the proper authorities under restrictions.

b. Modified quarantine contemplates that the same restrictions shall apply as in absolute quarantine, except that certain members of the family can enter and leave the premises if they take precautions, while the sick person is required to be isolated in a certain part of the premises.

c. Absolute isolation includes certain special measures of technical interest.

d. Modified isolation includes confinement of the patient and attendant in certain rooms, while the other members of the household are allowed to enter and leave as they please.

e. Special isolation includes prohibiting the patient from attending any public assemblage, providing separate sleeping apartments, eating utensils, towels, and napkins for the patient.

f. Complete disinfection includes the disinfection during illness, under the physician, of patient's body, of all excretions or discharges, of all clothing and utensils used by patient; after illness is over, the disinfection of walls, woodwork, furniture, bedding, etc.

g. Partial disinfection includes disinfection of discharges or excretions of patient, the clothing, and the room occupied by patient during illness.

RULE 6. All disinfection required by these rules shall be done according to the method recommended by the Texas State Board of Health.

RULE 7. When he receives information to the effect that a contagious disease exists in his territory, the local health officer is required to placard the house with a flag or a card of a certain size and bearing the inscription "Contagious Disease."

RULE 8. After a house is placarded, and placed under quarantine, no person except those authorized to do so by the local health authority is allowed to enter or leave the premises or carry away from the premises any article by which the disease might be spread. This rule holds until the premises have been disinfected and released from quarantine.

RULE 9. When any person is exposed to a contagious disease, it is his duty to follow the instructions of the health officer, in order to avoid the spread of the disease.

RULE 10. No person affected with any contagious or quarantinable disease shall be allowed to ride in any public conveyance, or to be present in any public assemblage, or to travel any public thoroughfare.

RULE 11. It is unlawful for any person to remove or destroy the quarantine placard, and if it is removed, the owner of the premises shall report this fact to the local health authority within twenty-four hours.

RULE 12. The following diseases are not only quarantinable, but are pestilential, and persons suffering from any of them are to be kept in absolute isolation, and the premises are to be absolutely quarantined as described in Rule 5, and complete disinfection must be performed after the termination of the illness: Asiatic cholera, plague, typhus fever, yellow fever.

RULE 13. The following diseases are dangerous contagious diseases, and persons suffering from any of them are to be placed in modified isolation, under modified quarantine, and complete disinfection must be performed after the termination of the illness:

leprosy, smallpox, scarlet fever (scarlatina), diphtheria (membranous croup), and dengue.

RULE 14. The following diseases are to be treated by special isolation and partial disinfection: typhoid fever, cerebrospinal meningitis, epidemic dysentery, trachoma, tuberculosis, and anthrax.

RULE 15. The following diseases are quarantinable for school purposes, and persons suffering from these diseases are barred from school for twenty-one days: **Persons suffering from measles, whooping cough, German measles (roetheln), and chicken-pox shall be required to be barred from school for twenty-one days (at the discretion of the local health officer) from date of onset of the disease, with such additional time as may be deemed necessary, and may be readmitted on a certificate by him attesting to their recovery and non-infectiousness.**

RULE 16. **Minor diseases are to be excluded during illness. Those actually suffering from tonsillitis, itch (scabies), impetigo contagiosa, and favus shall be excluded from school during such illness and be readmitted on the certificate of the attending physician attesting to their recovery and non-infectiousness.**

RULE 17. Additional precautionary measures may be instituted at the discretion of the local health authority.

RULE 18. When the local health officer hears of the existence of any contagious disease within the territory over which he has jurisdiction, it is his duty to investigate and if necessary declare a quarantine.

RULE 19. The local health officer is required to see that all quarantine in his territory is properly enforced, and that disinfection, when required by law, is properly done. Persons exposed to smallpox, if unvaccinated, are required to be held for eighteen days from date of last exposure.

RULE 20. No person shall offer for rent any building in which a case of any quarantinable disease has occurred, without previously having the building disinfected. This refers especially to houses which have been occupied by consumptives.

RULE 21. If disinfection is not performed as required, the house in which the contagious disease has occurred shall be placarded by the local health officer.

RULE 22. Nurses and midwives are required to report within twelve hours the presence of sore eyes or inflamed lids in the newly born; this reoort is made to the local health officer or to any reputable physician.

RULE 23. When any quarantinable disease occurs, it shall be the duty of the householder in charge of the premises to report the presence of the disease to the local health officer. In the presence of a quarantinable disease, before quarantine is established, it is unlawful for any person to move out of the infected house or to remove any articles from the house.

RULE 24. No person suffering with any reportable disease, or who resides in a house in which there exists a case of smallpox, scarlet fever, diphtheria, or typhoid fever, shall work or be permitted in or about any dairy or any establishment for the manufacture of food products, until the local health authority has given such a person a written certificate to the effect that no danger to the public will result from his or her employment or presence in such establishment.

RULE 25. When he is notified of the presence of smallpox or other quarantinable disease, the local health officer shall send immediately to the physician, or with his approval, to the patient, printed matter published by the State Board of Health relating to such cases.

RULE 26. Persons suffering from trachoma (granulated lids, contagious catarrhal conjunctivitis) are to be excluded from the schools unless they are under the strict supervision of a physician and hold a certificate to the effect that active inflammation has subsided; and this certificate must also be signed by the local health officer.

RULE 27. When any person suffering from smallpox, scarlet fever, or diphtheria is found to have been in a school room, the school must be closed until the building has been properly disinfected under the supervision of the local health officer.

RULE 28. In the event that the disease causing the closing of the school shall have been smallpox, the school must remain closed for eighteen days, unless the trustees require the vaccination of all unvaccinated pupils and teachers. In the latter case, the school may be reopened at once after disinfection.

RULE 29. The local health authority shall notify the superintendent or principal of any school of the locations of quarantinable diseases, and if the superintendent or principal finds any attendants in such schools who live in said houses, he shall deny them admission to the said schools, only admitting them again upon the presentation of a certificate from the attending physician, countersigned by the local health authority, attesting that there is no danger from contagion.

RULE 30. No superintendent, principal, or teacher of any school, and no parent, master, or guardian of any child or minor, having the authority and power to prevent, shall permit any such child or minor, having any quarantinable disease, or any child residing in any house in which any such disease exists or has recently existed, to attend any public, private, parochial, church, or Sunday school until the requirements of these rules have been complied with.

RULE 31. In cities and incorporated towns, the city health authorities shall assume control of quarantine, isolation, and disinfection; in districts outside of cities and towns, the county health officer shall assume control.

RULE 32. Cities, counties, and towns have the privilege of declaring quarantines independently of the State Health Authorities, so long as the additional quarantine is consistent with and subordinate to the quarantines established by the Governor and State Board of Health. In case any local health authorities declare a quarantine, they are required to notify the State Board of Health.

RULE 33. All health authorities have the privilege of passing through quarantine lines, provided they announce that they are acquainted with the disease they are visiting and will take precautions to prevent its spread.

Vital Statistics

RULE 34. Each birth occurring in Texas shall be reported by the physician, surgeon, or midwife, or in the absence of these, by the parent, to the city or county registrar.

RULE 35. Undertakers shall report each death to the local registrar, and the individual or firm selling the coffin is considered the undertaker.

RULE 36. All births and deaths, except those occurring in a city or incorporated town, shall be reported to the clerk of the county court; in cities and incorporated towns, births and deaths are reported to the city registrar.

RULE 37. Each city or incorporated town is a primary registration district. The city health officer shall be the local registrar. Each local registrar shall appoint a deputy to serve during his absence or disability, and both registrar and deputy are subject to the rules of this Code; provided, that in cities or towns where the secretary or other official is serving as local registrar, and where a burial or removal certificate is required before allowing any dead body to be buried within or removed from the city limits, such city secretary shall continue as the local registrar, but shall be subject to the regulations of this Code. No body must be removed from or interred in any local registration district until the local registrar has issued a burial or removal certificate, and such certificate shall not be issued by the local registrar until he has received and filed the death certificate as described later; but a death or removal certificate issued in accordance with the law of the place the death occurred, whether in Texas or not, shall be sufficient authority for the local registrar to grant a burial permit; in this case, the local registrar shall write plainly across the face of the copy of the record which he sends in to the State Registrar the fact that the body was shipped in for burial. The city registrar is required to record in a permanently bound book all births and deaths, with the statistical data required by law, and at the end of each month the city registrar shall forward to the State Registrar a copy of each birth or death certificate filed with him during the month.

RULE 38. All certificates of births and deaths shall be made according to the form prescribed by the State Board of Health.

RULE 39. For each dead body for which he provides a coffin, the undertaker shall fill out the death certificate, and shall turn the certificate over to the physician for the latter to give a signed statement as to the cause of death. The undertaker or physician shall then send the death certificate to the local registrar.

RULE 40. It is the physician's duty to be prompt in filling in the medical particulars of the death certificate.

RULE 41. In rural districts, where no undertaker officiates, the last attending physician shall hand in the death report.

RULE 42. Where a person dies without medical attendance, the coroner, if one is called in, shall file the death report; if no coroner is called in, the householder on whose premises the death occurred shall report the death to the local health officer; the latter shall issue the death certificate, after holding an autopsy if necessary.

RULE 43. If a death occurs in a hospital, certain statistical facts are required to be given by the superintendent of the hospital before the undertaker sends in the report.

RULE 44. If any physician, coroner, or superintendent of any hospital refuses to fill in the medical particulars on the death report, the undertaker shall report such person to the State Registrar for prosecution.

RULE 45. This relates to stillbirths, which shall be reported as both deaths and births.

RULE 46. The county clerk in each county shall preserve a bound record of all data contained in death and birth reports, and shall report monthly to the State Registrar of Vital Statistics.

RULE 47. Each sexton of a cemetery is required to file all burial permits received, and to send in a monthly report of all bodies interred to the State Registrar of Vital Statistics.

RULE 48. The State Registrar is required to have printed all death and birth certificates, while the city and county governments are required to have printed the permanently bound book for preserving birth and death records. The State Registrar has authority to require additional information about any birth or death from any person in possession of the facts.

RULE 49. The city and county registrars are required to furnish the birth and death certificate blanks to all persons using or requiring them.

RULE 50. The city or county registrar shall examine certificates of birth and death to see that they are complete. He shall number the births and deaths in separate series, commencing anew at the beginning of each year.

Depots, Railway Coaches, and Sleeping Cars

RULE 51. No person known to be suffering from smallpox, diphtheria, measles, scarlet fever, or whooping cough shall be allowed to enter or ride in any railway coach or street car, and in case any such person is discovered in such car, it shall be the duty of the conductor to notify the nearest health officer, who shall remove and isolate the patient as required by law.

RULE 52. All depots, railway coaches, interurban cars, and street cars must be properly ventilated and, in cold weather, heated.

RULE 53. Cuspidors in adequate numbers must be provided in all depots and waiting rooms, as well as in railway coaches; these cuspidors must contain at least one third pint each of some approved disinfectant solution, and must be cleaned out every twenty-four hours.

RULE 54. Dry dusting and sweeping are prohibited at all times in waiting rooms of depots and railway stations, and in railway coaches, interurban cars, and street cars.

RULE 55. Railway day coaches shall be thoroughly cleaned according to the method described by law at the end of each trip, or at least as often as once in forty-eight hours, when in use.

RULE 56. Railway waiting rooms shall also be cleaned in a sanitary manner once in each twenty-four hours.

RULE 57. Parlor, buffet, and dining cars must be thoroughly cleaned at each terminal; food-boxes, refrigerators, closets, drawers, and cupboards must be cleansed, scalded, and disinfected with an approved disinfectant.

RULE 58. Interurban and street cars must be washed with a hose and scrubbed thoroughly once every twenty-four hours; any such car must be fumigated immediately after any case of contagious disease has been discovered therein.

RULE 59. Sleeping cars must be cleansed thoroughly and disinfected at least twice in each week, except that on certain lines designated by the President of the State Board of Health, one cleansing and one disinfection per week may suffice; any such car must always be disinfected, however, immediately after any one suffering from any contagious or infectious disease is discovered therein.

RULE 60. In each passenger car operated in Texas, a signed record must be kept showing the place and date of each disinfection, the length of time devoted to such disinfection, and the name of the person doing the disinfecting.

RULE 61. All depots, railway coaches, interurban cars, and sleeping cars must be provided with a water cooler for the use of patrons; these coolers must be kept sanitary, must be cleansed once in each twenty-four hours, and the ice used therein must be handled with tongs, and not dumped on floors, sidewalks, or car platforms.

RULE 62. Expectorating or spitting on the floors, walls, or furniture of any depot, waiting room, platform, or any street car, railway coach, or interurban car is prohibited, and placards must be displayed calling the attention of the public to this fact.

RULE 63. Brushing of teeth or expectorating in basins used for lavatory purposes is prohibited, and placards announcing this fact shall be hung in proper places.

RULE 64. Sleeping-car companies shall provide separate compartments for their negro porters.

RULE 65. Negro porters shall not sleep in sleeping berths nor use bedding intended for white passengers.

RULE 66. No waiting room in any railway station or depot shall be floored in part or entirely with burlap or cocoa matting.

RULE 67. All depots and railway stations shall be provided with water closets which shall be so constructed as to exclude flies; these water closets shall be kept in sanitary condition, and shall be cleaned, emptied, and disinfected at least once in each thirty days.

RULE 68. The premises of all railway stations shall be thoroughly drained, so that no stagnant water shall collect thereon.

RULE 69. All cisterns, fire water-barrels, or other water containers upon the premises of any depot or railway station shall be screened with not less than 16-mesh wire gauze.

Note. — The rules governing the transportation of dead bodies are omitted. They are of technical interest, and can be obtained from any railway or express agent.

APPENDIX C. SANITARY AND UNSANITARY OUTHOUSES

In the state of Texas there are a good many of the class of boys that believes in carrying into effect what they learn. Many of these boys are Boy Scouts. For these energetic and intelligent young men the following directions for making a sanitary privy, such as the one shown in Figures 245, 246 and 247, are given.

The three things necessary in closets are as follows: First, flies must be absolutely excluded; second, the closet must not overflow and drain into the well; third, the waste must not flow out where it can be stepped on by barefooted boys, who might in this way get hookworm. Many boys will find that they

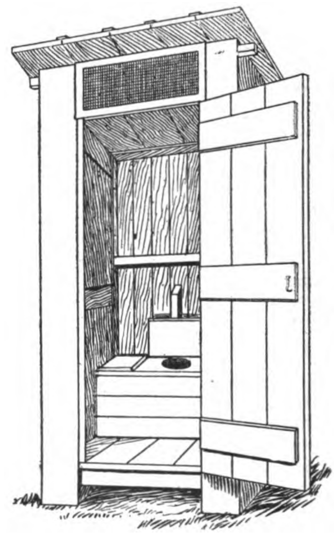


Figure 245. — When the lid is dropped, flies cannot reach the receptacle.
Figure 246. — Notice the screened windows or ventilators, and the trap-door on the seat. The building should be neatly painted.

can modify the water closet which they already have so as to make it fulfil all these three requirements. For instance, a few yards of wire screen well placed will exclude flies with absolute certainty. A watertight tub or other vessel can be placed underneath to catch the waste materials, and this tub must be emptied at intervals of a week or two. It should be treated with some disinfectant each day or two; probably the coal-tar disinfectants referred to in Chapter XIX are the best. Quicklime (unslacked) is also good.

For making an entirely new closet (and this would better be done where there is any doubt at all about the possibility of fixing up the old one), order the following materials: One piece 6 × 6 inches, 8 ft. long. One piece 4 × 4 inches, 16 ft. long. Five pieces 2 × 4 inches, 16 ft. long. Three pieces 1 × 6 inches, 16 ft. long. Two pieces 1 × 9 inches, 9 ft. long. Three pieces 1 × 10 inches, 7 ft. long. Fifteen pieces 1 × 12 inches, 12 ft. long. Twelve pieces ½ × 3 inches, 16 ft. long. Two pounds 20-penny spikes. Six pounds 10-penny nails. Seven-feet screen, 15-mesh, galvanized or copper, 12 inches wide. Four hinges, six-inch strap. Two hinges, six-inch, "T" or three-inch butts for cover. One coil spring for front door.

Having secured this material, cut up the wood as follows:

A — Two pieces of lumber 4 feet long and 6 inches square at ends.

B — One piece of lumber 3 feet 10 inches long, 4 inches square at ends.

C — Two pieces of lumber 3 feet 4 inches long, 4 inches square at ends.

D — Two pieces of lumber 7 feet 9 inches long, 2 × 4 inches at ends.

E — Two pieces of lumber 6 feet 7 inches long, 2 × 4 inches at ends.

F — Two pieces of lumber 6 feet 3 inches long, 2 × 4 inches at ends.

G — Two pieces of lumber 5 feet long, 2 × 4 inches at ends.

H — One piece of lumber 3 feet 10 inches long, 2 × 4 inches at ends.

I — Two pieces of lumber 3 feet 4 inches long, 2 × 4 inches at ends.

J — Two pieces of lumber 3 inches long, 2 × 4 inches at ends.

K — Two pieces of lumber 4 feet 7 inches long, 6 inches wide, and 1 inch thick. The ends of *K* should be trimmed after being nailed in place.

L — Two pieces of lumber 4 feet long, 6 inches wide, and 1 inch thick.

Having sawed the lumber into the right sizes, put it together as follows, referring to Figure 247 as a model:

First lay down the sills marked *A* and join them with the joist marked *B*; then nail in position the two joists marked *C*, with their ends 3 inches from the outer edge of *A*; raise the corner posts (*D* and *F*), spiking them at bottom to *A* and *C* and joining them with *L*, *I*, *G*, and *K*; raise door posts *E*, fastening them at *I*, and then spike *J* in position; *H* is fastened to *K*.

After the frame is erected, the sides, floor, roof, seat, windows, and doors can be built as shown in Figures 245 and 246. These pictures and directions are borrowed from Public Health Bulletin

37, written by Dr. C. W. Stiles and issued by the U. S. Public Health Service. The bulletin may be had by writing to the Service at Washington, D. C. Somewhat fuller instructions will be found in the bulletin than in this chapter.

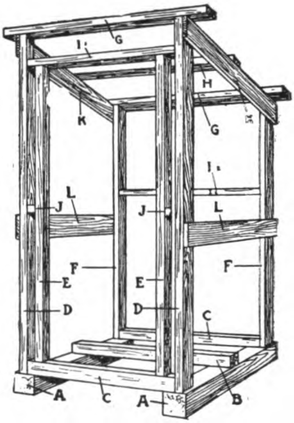


Figure 247. — This shows how to erect the frame for a sanitary closet. (See instructions on this and the preceding pages.)

It might be further suggested that the school grounds should not only be sanitary but also beautiful. The outbuildings should be rendered as inoffensive to good taste as possible. They should be painted, both for the sake of appearance and for durability. The privies should be screened from general view. This screen should consist, not of an ugly board fence, but of an arbor of plants. A trellis of lattice work covered with a hardy, perennial climber, such as the Cherokee rose or honeysuckle, would be very pretty. A hedge of shrubbery would be still better and more permanent. Georgia cane makes a good background against which such evergreens as California privet, youpon, cedar, or wild peach could be grown. For full directions on beautifying the school grounds consult Farmers' Bulletins Nos. 134 and 185 of the U. S. Department of Agriculture, Washington, D. C. and Bulletins of the Department of Extensions, University of Texas.

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A star (*) after a page number indicates that the subject is illustrated.