Mary E M Drummond

THE GULICK HYGIENE SERIES

EDITED BY

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PHYSIOLOGY, HYGIENE AND SANITATION

BY

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PREFACE

It is the purpose of this volume to present such material on physiology, hygiene, and sanitation as may be of practical service to young people. For this reason function is emphasized rather than structure, and the laws of health receive more attention than the mechanical operation of bone, muscle, gland, and tissue.

In the earlier chapters of the book stress of teaching is laid on right habits of sitting, of standing, and of walking; on the relation of the school desk to spinal curvature; on laws of growth and their relation to correct habits of posture; on the development of muscular vigor; and on the renewal of the tissues of the body.

Attention is also called to the source of all muscular energy — the blood. Simple tests, easily applied, explain the cause of rapid and slow heartbeat and show how the power of the heart and of the lungs may be increased gradually. Reasons are given why the untrained heart should not be greatly taxed, and why extreme breathlessness is objectionable. The effect of alcohol on the heart and on the arteries is made plain, and the effect of tobacco on the action of the heart is illustrated by means of the sphygmograph.

Professor Chittenden's notable experiments with soldiers in New Haven and Dr. Cannon's experiments with cats in the Harvard Medical School add a touch of picturesque reality to the otherwise prosaic subject of digestion. Through these experiments we are introduced to the change of food from solid to liquid in the alimentary canal, to the absorption of chyle by the villi, to the enrichment of the blood, and to the work of the liver and the kidneys in purifying the blood.

The nervous system also is studied primarily from the point of view of function and of efficient service. The student learns how the body is controlled by laws of habit and by will power, how habits are formed, and how it comes to pass that a happy state of mind helps on the cause of good health.

The present volume is, in some respects, a readjustment of *The Body and its Defenses.* Certain subjects treated there have been pressed into smaller compass here; while certain other subjects touched upon there have received more extended treatment here. To a large extent this new subject matter concerns itself with sanitation, hygiene, and the food requirements of the body. The following are a few of the new topics interspersed among the old: rules for right eating; balanced menus; food for bulk; food waste; why we cook our food; pure-food laws, and food inspection; canned foods; patent medicines; mistakes in eating;

auto-intoxication, how brought about, how avoided; headache and auto-intoxication; the relation of alcohol to taxes, crime, and poverty; treatment of the eyes; hygiene of the ear.

A new feature of this book is its chapter on sanitation, where contrasts are drawn between country conditions and city surroundings; between the solution of sanitary problems for congested cities and for scattered country communities.

Still another chapter shows how our common microbe diseases — measles, scarlet fever, malaria, smallpox, diphtheria, yellow fever, etc. — are passed about, and how we may escape them through vaccination, antitoxin, cleanliness, and general physical vigor secured through the observance of the laws of health.

In this volume, as in *The Body and its Defenses*, tuberculosis is studied — its cause, its prevention, and its cure; also typhoid fever as related to pure water and clean milk; also dangers from the public drinking cup and the public towel, from the fly, the mosquito, the hookworm, and the rat.

These and other related topics have been brought to the notice of the students of this volume with the hope of imparting such enthusiasm for personal health and such clear notions of how to secure it that healthful habits may result; that the bodies of growing children may be strengthened as well as straightened; that lives may thereby be lengthened; and that through increased physical well-being the sum of human happiness may itself be increased.

For the convenience alike of teacher and of pupil, side-headings serve as a ladder of connected topics throughout the book. A series of questions is also added to each chapter, and many illustrations reënforce the teachings of the text. Special mention should be made of indebtedness to the *American Journal of Physiology* for illustrations used by Dr. Cannon in his article on "The Movements of the Stomach studied by Means of the Röntgen Rays," and to Professor Chittenden for photographs of the soldiers with whom he carried on his food experiments.

Other valuable illustrations have been reproduced from *The Human Mechanism* by Theodore Hough and W. T. Sedgwick, from *Alcohol and the Human Body* by Sir Victor Horsley and Mary D. Sturge, and from *Unser Körper* by F. A. Schmidt. To each of these and to many other important works this small volume is indebted not merely for illustrations but also for valuable facts which have been used in the preparation of its subject matter.

F. G. J.

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PHYSIOLOGY, HYGIENE AND SANITATION

CHAPTER I

CHANGELESS RECORDS

Taking the Body's Record. Certain cities are able to keep changeless records of their criminals who have been captured. City officials measure each man carefully — his height in standing and in sitting; the distance from the outstretched finger tip of one hand to the outstretched finger tip of the other; the length and width of head, face, and right ear; the length of left foot, of left middle finger, and of left forearm. Scars are noticed and recorded; also the color of hair and eyes, the shape of the nose, the number of teeth, etc. Each item is important as part of the final, full record.

TAKING HIS RECORD WHEN SEATED

A Caliper Compass measures the Length of his Head

In addition, a photograph is taken. And, strange though it may seem, a photograph is less important than measurements in identifying a man if he is ever arrested again and brought to the police station. The reason is that our bone measurements change little after we are twenty-two. Ever after that the size of face and head, the length of arms, of fingers, and of legs, remain practically unchanged.

The Middle Finger is Measured

This, then, is a sure and sensible way of keeping the record of a man. When a criminal is under examination, no matter how violently he declares that he has never been arrested before, the officers measure him at once, then search their written records. If they find any set of measurements which is a duplicate of those just taken, all the man's denials are in vain. Those officers know that never yet have two people been found who had precisely the same dimensions for all the bones which were measured.

It takes but ten minutes for the officers to get their record of a man — photograph and all. But it took the man himself twenty-two years to form the body which is now his physical record of himself; and the training began when he was very young.

CHINOOK BABY IN HIS CRADLE

The weight on his forehead will help turn him into a flat-headed Indian

When Cartilage turns to Bone. Notice any careful mother with a baby in her arms. See her firm hand against the back of the head as she holds the child up for a look at the world. She knows that for months there is more cartilage than bone in the supports of a baby's body, and that while bones are in this condition they cannot be trusted to do independent work.

Certain Indians have known this for centuries. A famous tribe that admired flat-headed men secured these heads for their boys by a clever contrivance. They simply fastened a board by a hinge to the head of the cradle and allowed it to press down upon the forehead of the baby whenever he was strapped in place. As months passed, the small skull not only continued to grow but also set itself hard and firm in the desired shape. And, once firmly set, there was never any hope that the grown Indian could restore his head to the perfect shape which it had when he was born.

Thus some of our bones and muscles are trained by other people before we are old enough to make decisions for ourselves. Yet, whoever is responsible for results, two laws of bone growth should never be forgotten:

1. Many bones can be compelled to take a bend in this direction or that while the child is growing.

2. Almost no bone can be forced to make a new bend after it is twenty years old.

But there is other training which is more complex, and for which we ourselves are responsible.

Making Our Own Records. On a certain day two boys entered the same shop and asked for work. The first boy was refused, the second was accepted. And the explanation lay with the bones and the muscles, which had made different records for the two bodies. The first boy walked with a shuffle and had a slouching body. Before he had spoken a word the business man who met him was unfavorably impressed and ready to reject him.

The second boy walked as if he respected his body thoroughly. His head was erect, his shoulders well squared, and the vigor of his body gave the impression that he was in the habit of doing things with energy. This boy was accepted as promptly as the first was refused.

How the Right Kind of Body Helps. Let two women enter a store or a schoolroom, a theater or a church. Which will be served most quickly, she who shuffles as she walks, has crooked shoulders and a head thrust forward, or the woman who steps forward gracefully, who walks as if her body were under her command, as if it were her true representative? Surely the second woman is queen wherever she goes. Without question, at every stage of growth the body proclaims the story of what has happened to it and of all that it has done with itself since it began to live. It is also true that we have it more or less within our own power, while we are growing, to make the records which are to represent us the rest of our lives.

If a man by his own acts or his own carelessness must live miserably in a shanty when he might have lived gloriously in a palace, we are apt to blame him more than we pity him.

Testing Yourself. For the sake of making discoveries about yourself, stand before a mirror and study the outlines of your back, your chest, your shoulders, and your legs. Try to stand precisely as you do every day at home and at school, so that you may get a correct notion of the records your bones and muscles have made for you thus far in your life.

He stands Well

Notice his chest and his shoulders

The Same Boy at Another Time

He lessens his lung capacity

Be keenly critical. Are you standing squarely on both feet? Are your knees bent or straight? Is your back erect enough to hold your head up where it belongs, or does your head droop forward so that your chin sticks out too far? Is one shoulder higher than the other? Is your chest rounded out like that of a soldier, or does it sag like a valley between your shoulders? Rub your hand across your back to see whether or not a corner of a shoulder blade reaches out, like a young wing starting from the wrong place.

If you can give creditable answers to these questions, your future course is easy. Simply keep on growing as you have begun, and in the course of time you will have the shape you wish. If, on the other hand, you are dissatisfied with what you see, put each point right while still looking at yourself in the mirror.

Back View

Notice his shoulders and his curved backbone

The Correct Standing Position. Stand with both feet on the floor, each bearing its own share of weight, both knees unbent, both shoulders square and on a level with each other. Draw in your chin until the back of your neck would touch a stand-up collar. Inhale a breath so full and deep that your chest looks like that of a drum major in his regimentals. Now your back has its correct shape for standing.

The Correct Sitting Position. Make another test. Sit with feet squarely on the floor, back straight, head erect, and chest raised. Are you comfortable? Can you draw a full, deep breath? Test this thoroughly.

Now slip down in your seat, curve your neck forward, let your back be bent, let your chest fall in, and once more

RIGHT POSITION FOR READING

His lungs have ample space

WRONG POSITION

He curves his back and crowds his lungs

try to take a full, deep breath. Notice that you cannot do this now, because you have cramped your lungs.

Sit now with one elbow on the desk, or with one foot drawn up under you, or with some bend at the waist line that will give a twist to the spine near the hip. The objection to taking any one of these as the usual position is that gradually the relation of the bones to each other will be so altered as to distort the body. In no wise does it harm any of us to twist this way and that, to bend as far as we can in one direction or another. Indeed, all such exercise is good for the body, provided no position is taken often enough, and held long enough, to become habitual.

Lateral Curvature of the Spine. Dr. F. A. Schmidt, a scientific writer in Germany, says that Dr. W. Mayer examined the backs of three hundred and thirty-six girls and found that one hundred and eighty-nine of the number had what is called lateral curvature of the spine. He found that girls between seven and thirteen years of age had much more trouble than those who were under seven, and he concluded that the habits of sitting formed at the school desk explained the difference, because the older children had spent more hours, days, and years in the schoolroom than those who were younger.

Follow for yourself the work of muscle and bone, and understand what happens when a child gets into the habit of sitting at his desk with elbow up on one side, shoulder lifted, and body half screwed round. Notice that if you tip up one hip the spine curves sidewise, as a balance. If you raise one shoulder, it pulls the spine accordingly. Evidently each separate movement of the muscles of the back influences the curves of the spine, and the same curves repeated day after day at the same desk mold the bones, and the cartilage which lies between them, in wrong positions until they are as truly pressed into a new shape as if the change were planned for.

The main objection to such curves is that if they are allowed to remain and to become habitual, they will interfere with the successful working of the large organs of the body. Then, too, when a curve becomes permanent — although it may be small—the nerves themselves are often affected by it, and the body suffers at the point which is supplied by these nerves. A person enduring this pain may not know its cause, but his ignorance will not save him from suffering.

Bad for the Back

If this position is taken every day for long periods, the vertebræ will become wedge-shaped

How to prevent Lateral Curvature. Let us form habits that will help us to prevent spinal curvature. Children may save themselves by being careful to balance the exercises which they allow the muscles of their backs to take. All that is needed is a little knowledge and a firm purpose. Whoever allows himself to be shaped by undesirable habits of muscle and bone will have cause for keen regret in later years. But he who, in his youth, controls his habits and shapes his body with care will never regret it. Instead, he will have a body that will be an honor to him for the rest of his life. Four rules will help:

1. Do not sit day after day in the same twisted position. Change frequently.

2. Do not carry a heavy weight of books on the same arm back and forth from school every day. Carry as few books as possible, and let each arm do its share of the work.

3. Do not carry a baby brother or sister on the same hip every day. Indeed, it is best to do little carrying on either hip. The weight, placed just there, will tend to give a wrong twist both to your back and to his.

4. If you must stand for hours at a stretch, learn to rest one leg by using the other. Don't let one side sag down habitually. Change sides.

QUESTIONS

1. How do cities get and keep records of criminals? 2. Which is the more accurate record of a person — a photograph or measurements? 3. After what age are bones set for life? 4. Why does a mother support the head of a young baby when holding it? 5. Give two laws of bone growth. 6. What effect does an erect, healthy body have on a boy's chance of success? 7. In what ways does the body tell facts about us?

8. Test your own body to see if you stand correctly. 9. What sitting positions are objectionable, and why? 10. What difference is there between sitting with a twist in the back once in a while and taking that position most of the time? 11. What must be guarded against? 12. Do older or younger girls have more trouble from lateral curvature of the spine? 13. Why is this? 14. Mention various positions that bring curves to the spine. 15. What objection is there to these curves? 16. Give four rules for preventing them.

CHAPTER II

MUSCLES: WHAT THEY ARE AND WHAT THEY DO

The Strong, Bent Back. The coal heaver round the corner has a superb set of muscles over the working part of his back. They are so well developed that, as he stands bent over his work, it is evident that these muscles give him a back of tremendous strength. By their help he shovels coal for hours at a time, through the days and weeks of the year. Moreover, when he has finished his day's work he does not seem overtired. He even jokes at the expense of his own back, for although it is so well developed and so tireless, still the man himself frankly acknowledges that it is sadly bent, and that by no effort on his part can he stand straight or walk as would please him best. He says that this is the price he has had to pay for the kind of work he has chosen.

Bent by his Work

Multitudes of people have round shoulders developed in some such way as this. Notice their shape, know about their occupations, and draw your own conclusions.

Bent by Bicycling

A bicycle rider whom I know has a back quite as bent, *not so much from the work it has done as from the position it has been allowed to maintain.* It is muscular, strong, and efficient, but it never looks well except when he is working his legs fast on his wheel.

Something must be wrong, and we wonder what it is. Here are these men, and multitudes of others, whose backs are well developed, but who are so bent as to look almost deformed. For years no one could entirely explain the cause of the combination — a strong but bent back. Close observation and logical reasoning have answered the question, however, for we learn that *muscles stay in the position in which they do their heaviest work.*

Effect of Work on Stretched Muscle. A traveling man whom I know says that when, for a few weeks, he carries his suit case persistently with his right hand, the right shoulder becomes an inch or an inch and a half lower than the other, while at the same time it becomes stronger. This shows that a muscle can be lengthened even while it is being strengthened.

Bent by Age

Two oarsmen row with all their might. One does it with a straight back, the other with a curved back. Their work continues day after day, until one back is as strong and as muscular as the other. But see the results. One man walks as if he had spent his boyhood curved over a school desk without a thought about what was happening to his spine. The other man looks as if he might have spent those same years at West Point, with officers and fellow students who compelled him to stand straight whether he wished to or not. Yet the boyhood of the two men may have been alike. The difference just now depends upon their postures while they were rowing. Their muscles, when they walk, simply betray some facts about their recent history.

To Balance Development. Fortunately, however, there is a happy outlook even for such people as are obliged to work with their backs bent, for there is another important fact about this law of contracting and stretching. I give it concisely:

Brief, vigorous exercise in the right position will undo much of the harm of long-continued exercise in the wrong position.

If a man who works in a bent posture all day will spend five minutes a day in taking vigorous exercise with his back straight, alternately tightening hard and then relaxing the muscles of his back and neck, he will find that within one month there will be an improvement. And the more faithfully the exercise is continued afterwards, the more good will it do. By this simple device a man may save himself from his rounded back and be able to hold his head where it should be.

It often happens that the muscles of the chest become thin and flabby for lack of exercise, even while the back has become very strong. But these muscles may be saved. Throw the shoulders well back and exercise the chest muscles hard in this position. Exercise them while they are thus stretched, and they will grow large and prominent in spite of what your occupation may be. If the exercise can be taken oftener than once a day, it will be so much the better.

The Law of Muscle Change. In this work of changing the shape and the power of a muscle, the greatest strain must be put on the last third or the last quarter of the contraction. Remember that each muscle is inclined to stay in the shape which it takes when it does its hardest work; in other words, the law is that *doing a thing makes the part shape itself for that act*. Evidently, then, to a large extent, we may develop our bodies according to our desire. Knowing this, a public lecturer — a doctor — told his audience that each man present could increase the size of his arms three quarters of an inch within one month and could increase his chest measure an inch and a half during the same length of time.

EXERCISE FOR THE BICEPS

One Way of Developing the Muscles. To show what he meant, the lecturer asked his friend, a medical student, to illustrate the points one by one as he himself explained them. The student was well knit and well built, no unnecessary fat concealed the shape of his muscles, and he was ready to show the other men what they also might do in behalf of their own development.

"Now," said the doctor, "show us the effect on the biceps of rotating the arm; the forearm; now rotate the leg — the big muscles; show that tensor. Now again will you go through four or five exercises that bring into play in succession first one arm, then the other, and so on?"

The student acted on the suggestions as fast as they were given. His smooth back and arms gave no sign of separate muscles while he stood quietly waiting to be told what to do, but as soon as he followed directions and used arm, leg, back, or shoulders, there sprang into prominence one set of well-developed muscles after another.

Well-developed Muscles

Antagonistic Muscles. The student held no apparatus, but used arms and legs as if he were pulling against some invisible weight. He was, in fact, pulling against the force of his other muscles — antagonistic muscles, they are called. Try this for yourself, with your forearm or with your back. Try to bring out one muscle and see how many others are called into action. The doctor then explained that muscles can be developed in this way with no apparatus whatever. "Muscles," said he, "can pull in one direction only; the opposite pull has to be done by antagonistic muscles." He made it plain that in arms, legs, and elsewhere, muscles are often placed in pairs, called flexors and extensors, which balance each other with their power of pulling. He showed that these opposing muscles can be developed without apparatus by making flexor muscles bend the limb, and extensors straighten it out again. It is flexor and extensor muscles that help us close and open our hands; help us curl up our toes and stretch them out again vigorously.

EXERCISE WITHOUT APPARATUS

Exercise without Apparatus. As he went on with his address, the doctor said that to make muscles develop, they should pull as hard as possible for a few seconds at a time, then let go completely, then pull again for a few seconds, and so keep up the alternation for five minutes in the morning, for five minutes at night, and for ten minutes a day between times. "To develop arm or chest," said he, "put in the extra ten minutes

HE DEVELOPS ARM MUSCLES

whenever convenient." It appears, therefore, that in many cases the process of developing one muscle or set of muscles may be carried on without apparatus and without the gymnasium.

Examine your own muscles. Decide which are firm, which flabby. If they should be improved, talk the matter over with any good gymnasium director. He will tell you what special daily exercise to take for special muscles. As for securing very big muscles, however, they are really of no advantage in the health line. Still the fact that up to a definite limit we have the power to increase the size of arm and chest and leg proves once again how truly each of us is master and architect of the body we are building.

TAKING THE MEASUREMENT

Studying Muscle Structure. But what about the substance out of which the body molds a muscle into shape and compels it to increase somewhat in size whenever it is forced to do unusual work? Get a piece of lean corned beef from the butcher; have it boiled thoroughly; place a board over it and press down upon it hard enough to squeeze out all the liquid; remove the board, and with a needle of some sort pick apart the fibers as well as you can. Pick them away from each other into finer and finer threads until you think you have reached the smallest ones of all.

Now, with a good magnifying glass, examine one of these bits of beef muscle. You are able to pull them apart because the tough outside wrapping of each has been changed by boiling.

Bundles of Fibers. However large or small a muscle may be, and wherever that muscle does its work, whether in creatures that walk, fly, or swim, every bundle of muscle is made up of fibers wrapped together. Shapes are different; size varies — from those that draw an eyelid up and down, to those that kick a football to its goal; the work of each is different; their strength and power of endurance are different; but each bundle is a combination of individual fibers. A few of these are wrapped together as a small bundle, small

MUSCLES OF DIFFERENT SHAPES

bundles are gathered into bundles that are larger, large bundles become larger yet, and thus from smaller to larger are the muscles built up. Each is a bundle of other bundles; each is adapted in size and shape to the special work which it must do; and every fiber in the bundles, large and small, is inclosed in what is called the sarcolemma. This sarcolemma, then, is simply an outer wrap that separates each fiber from its neighbors.

INDIVIDUAL MUSCLE FIBERS

END OF A MUSCLE FIBER

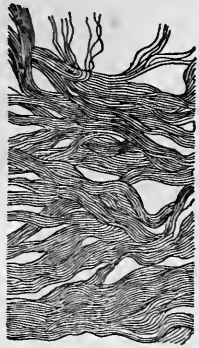
It shows fine threads which help form the tendon

Connective Tissue. In addition, however, there is a close network of substance called connective tissue, which holds the individual fibers together. In this connective tissue are the tiny blood vessels and the slender nerves which supply blood and stimulus to each smallest fiber. Fine threads of connective tissue also stretch away from each end of the muscle fibers and help to form the tendon. Each tendon is fastened to a bone.

A BUNDLE OF MUSCLE FIBERS

Each is covered with its own sarcolemma; connective tissue is between the fibers

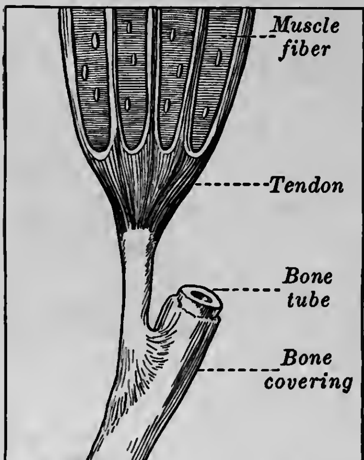
Tendons. Any tough bundle of tough fibers which holds muscles to the covering of the bone is called a tendon. Examine your wrist. Open and shut your hand by the use of extensor and flexor muscles. Notice the movement of the long slender tendons that connect the fingers with muscles in the arm. The foot is moved by tendons that reach up to the muscles of the leg. This use of long tendons gives the body its slender wrists and ankles. Some muscles end in tendons fastened to bones at a distance. Some have short tendons fastened to bones near by. But, whether long or short, whether large or small, all tendons are needed to help muscles pull the bones in definite directions. And the muscle itself does its work by contracting and relaxing.



TENDON, GREATLY MAGNIFIED

It shows fiber bundles separated

Draw up the muscle in the calf of the leg. It has tendons fastened to the lower end of the thigh bone and to the heel bone. The contracting of the muscle is done between these two firmly held points, and because of this contraction we are able to walk, run, dance, and kick. The biceps muscle of the arm has tendons which hold one end of it to the shoulder, the other end to a bone in the forearm. When the muscle contracts, the lower end is drawn up, not because the tendons contract but because they cling to the bones and so do the pulling. The wonder is that these tendons do not more often suffer under the sudden strain which we sometimes put upon them. When they do give way — as happens in a sprained ankle — it is often a more serious matter than a broken bone, because the outside covering of the bone is sometimes pulled away with the tendon, and the ends of a broken bone knit together much more easily than do the torn terminations of a tendon.



MUSCLE ENDING IN TENDON; TENDON FASTENED TO BONE

(After Schmidt)

Remember that when any muscle pulls any bone it is because each muscle fiber in the bundle has shortened itself and grown thicker. Indeed, it is the shortening of the fibers that compels the pulling. Double up your arm hard and prove this. The muscle is thicker because of the united work of thousands upon thousands of fibers. Although each separate fiber, then, is a part of the muscle as a whole, each is also a small independent center of power, doing its own work. But no single fiber carries its independence very far. Generally when its neighbors receive a command to go to work, it receives the same command. When they rest, it rests too. When they are destroyed by age or death, it endures all that they endure. Yet, after all, the work of the millions of fibers that are held together by connective tissue in a single muscle is really the sum of the work which the fibers do separately.

MUSCLES TIGHTENED AND SHORTENED FOR THE JUMP

(After Schmidt)

What makes Tough Muscles. More than this, it is the amount of connective tissue between the fibers that explains the difference between tough and tender meats. With age and exercise this tissue gradually thickens its substance during life, until finally certain muscles become too tough to be eaten without long boiling or steaming.

When, therefore, we speak of tough and tender meat, we really refer to muscles in which the connective tissue has or has not been toughened by age or exercise.

Let an athlete bend up his arm. You may try to press it with your hand, and it will resist you almost like a piece of wood. This is no mystery, for you understand that each fiber in that muscle has been toughened by use. If such a muscle were found in the shop of a butcher and offered for sale, a wise cook would refuse to buy it, because even boiling would not make it tender. But tough muscle in the arm of an athlete means that it is in prime working condition.

A RUNNING BROAD JUMP FROM ONE FOOT

It shows the work done by different muscles from the moment the man jumped until he stood on his feet again

(After Schmidt)

Two Classes of Muscles. The muscles which we have been studying belong to the skeleton. They are always attached to bones and are therefore called skeletal muscles. There are two great classes of muscles:

1. *Voluntary muscles*, of which there are five hundred, are under the power of our will. Through them we walk, run, climb, and swim; through them we talk, sing, play the piano, and crown ourselves with glory on the athletic field. Most of them are fastened to bones that are movable. Hand and head, arms, legs, fingers, mouth, tongue, eyelid, and eyeball — all are under our control because they are

SUPERFICIAL MUSCLES OF THE BODY

Each is fastened to bones that lie underneath moved by our voluntary muscles, which contract and relax at our bidding. Not so, however, do muscles of the other sort.

2. *Involuntary muscles* are independent of the bones, independent of our will, and far too numerous to count. They form the muscular sac of the stomach and the muscular tube of the intestines. They give muscular power to the arteries and form the entire substance of the heart. It is, in fact, the ceaseless contracting and relaxing of the involuntary muscles of our heart that keeps us alive, through the circulation of the blood. When heart muscles stop, life must soon stop. Each air sac of the lungs has its muscular wall, and each individual organ of the body has its own supply of involuntary muscles in constant service. All these are deaf to our commands, but they continue to be busy whether we sleep or wake, whether we stand or sit, walk or run, whether we laugh or cry. Whatever we do, they are unceasingly occupied with the internal work of the body, pumping the blood through heart and blood vessels, caring for the food we eat, and carrying on those vital processes over which we have no conscious control.

Weight of Muscles. Taken as a whole, the muscular machinery of any human being is as heavy as all the rest of his body weighed in a lump. A few separate muscles are given in the picture on page 27. Each does its own separate work, and all help in what the body does for us. But perhaps the biceps is the muscle best known to every boy.

Study the muscles on the chart and locate as many of them as possible on your own body. The intercostal muscles do not appear, being hidden under other muscles. They hold the separate ribs to each other.

QUESTIONS

1. Why do coal heavers have strong, bent backs? 2. What law explains such a back? 3. Mention such occupations as you think may change the shape of the body. 4. Give the second great law about muscles stretching and contracting. 5. How may a man who works in a bent position save himself from being permanently bent? 6. How can you show what muscles can do? 7. If a person exercises without apparatus, what does he pull against? 8. What is an antagonistic muscle? 9. How can muscles be developed without apparatus? 10. How often, and for how long a time, should such exercises be taken?

11. Define muscle fiber. 12. How may we examine the structure of a muscle closely? 13. Tell about the size and shape of different muscles. 14. Tell how muscles are formed. 15. What is the sarcolemma? 16. What is connective tissue? 17. What lies within it? 18. Of what use are the fine threads of connective tissue that stretch away from muscle fibers? 19. What do they help form? 20. What is a tendon? 21. To what bones are the muscles in the calf of the leg fastened? 22. What does the biceps pull up? How? 23. Why is a torn tendon often worse than a broken bone? 24. When is meat tough? tender? 25. Describe voluntary muscles. 26. What is the work of involuntary muscles? 27. Compare the weight of the muscles with that of the rest of the body. 28. Study the chart and name five muscles.

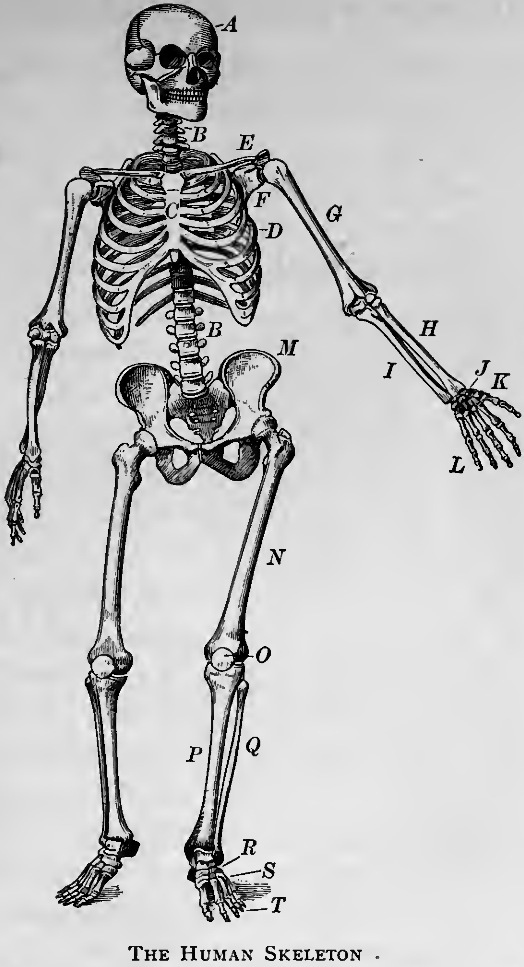
CHAPTER III

BONES — THE FRAMEWORK OF THE BODY

Bones and Muscles. A certain teacher who owned a skeleton used to throw it over his shoulder when he carried it from the storeroom to the lecture room. And as he walked it hung from his back, a clattering set of dangling bones. It is true that the separate bones were held together at the joints by artificial contrivances, but that was all. The skeleton could not have stood on its own unaided legs. Those who saw this group of bones and were instructed, understood as never before that bones are as dependent on ligaments and muscle to keep them together as are tendon and muscle dependent on bone to hold them in place.

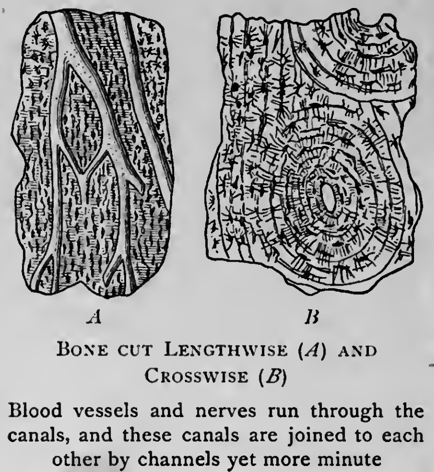
Bone Structure. Examine a bone fresh from the butcher's. Notice the outside — firm and closely woven, as it has to be to supply a surface for muscles to hold to. This bone-covering is the periosteum. It is a tough membrane, and tendons from the muscles are fastened to it.

Within the bone we find the texture much looser than that of the periosteum. We know now how it happens that the bone is not only large and strong but light and



THE HUMAN SKELETON

A, skull (22 bones); *B*, spinal column (33 vertebræ); *C*, sternum; *D*, ribs (12 on each side); *E*, clavicle (1 on each side); *F*, scapula (1 on each side); *G*, humerus; *H*, radius; *I*, ulna; *J*, carpal bones (7 in each wrist); *K*, metacarpal bones (5 in each hand); *L*, phalanges (14 in each hand); *M*, pelvis (4 bones); *N*, femur; *O*, patella (1 in each knee); *P*, tibia; *Q*, fibula; *R*, tarsal bones (7 in each ankle); *S*, metatarsal bones (5 in each instep); *T*, phalanges (14 in each foot) firm. It is indeed by no means a solid substance. A magnifying glass shows numerous tiny spaces in the body of the bone. One may also see smooth channels on the outside, along which the blood vessels ran, and tiny openings from the surface to the interior, into which the smallest blood vessels went to keep up the life of the bone.



BONE CUT LENGTHWISE (*A*) AND CROSSWISE (*B*)

Blood vessels and nerves run through the canals, and these canals are joined to each other by channels yet more minute

Chemical Composition of Bones. A chemist will take a bone and keep it in acid for a while. He will then tell us that he has taken out all the lime salts and has left nothing but organic, or animal, matter. He may now tie the bone into a knot to show how flexible it is. Taking another bone he will hold it in fire for a while; then, when touched, the whole structure falls to pieces—a heap of white powder. "This is mostly lime," he says. "I have burned out the organic part." A cook will take a meatless bone, boil it for several hours, and secure a jelly to add to her soups. This is gelatin from the animal matter of the bone. It proves that even a bone is of value and should not be wasted.

Young and Old Bones. These and other experiments show that bones are made up of so-called lime and an animal substance which becomes gelatin on being cooked. We also learn that the bones of old people contain much lime and are very brittle, while the bones of a child contain far less lime and are less brittle. This fact makes it unsafe for aged people to have even a tumble on the sidewalk. Younger bones can save themselves by bending a trifle.

TIED IN A KNOT

After acid has taken the lime from it

We understand now why children have so much power to shape their bones while they are young. It is because these bones are not yet firmly set with lime.

Decide for yourself why each of your bones has its own particular shape. Study the picture of the skeleton and learn as many of the names as your teacher requires.

A BONE CUT THROUGH LENGTHWISE

The outer layer is compact and firm, the inner substance is a network of canals and spaces; thus are bones both light and strong

Shape and Size of Bones. Each bone has its own particular shape: long ones for legs and arms; flat ones for

LOWER LEG WITH ITS MUSCLES AND TENDONS
(After Schmidt)

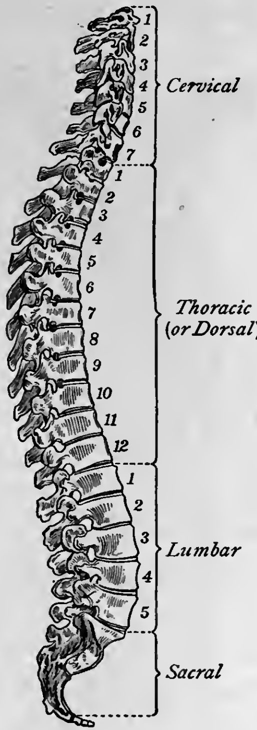
shoulder blades, breastbone, and hips; curved long ones for the ribs; curved flat ones for the skull. These latter are so closely interlocked that the head seems like a solid, single bone. There are queer, jagged bones, one above the other in a column, for the back, and many small bones of hand and foot deftly held together by ligaments. Each bone does its part in supporting the muscles and other soft parts, and in making them serviceable to us.

The shafts of the long bones are hollow, with delicate fat, called marrow, in the center. The short, flat, and square bones are spongy inside, with red marrow in the spaces.

The human skeleton is made up of two hundred separate bones, each with its special name. But perhaps the most important group is the column of vertebræ which forms the spine.

The Spinal Column. Many a man has lived for years without an arm, without a leg, without bones of various sizes and shapes; but no man would ever be able to live for a moment without that column of small bones that holds his head erect, that keeps his ribs in place, and that guards the treasure of his spinal cord.

In the spinal column each separate vertebra is held to the one above it and to the one below it by muscles and ligaments on each side, and because of their muscles and ligaments these individual vertebræ are no more responsible for the shape they take, or for the twists and curves they join in making when a gymnast bends his back from side to side, than are the dumb-bells and the pulleys which the same gymnast uses; for the bones of the spine simply rock back and forth or sideways upon each other, according as muscles on this side or that give the needed pull and move the bones.



A SIDE VIEW OF THE SPINAL COLUMN

Each group of vertebræ has its special name

To prevent too much jarring, each vertebra is separated from its neighbor by a thin elastic cartilage which acts like a cushion between them.

Wedge-Shaped Vertebræ. Just here recall a few facts. Young bones are somewhat yielding; they take new shapes if they are put under special, oft-repeated pressure. A child at a school desk easily gets into the habit of sitting with the vertebræ pressed against each other at the same angle every day. Muscles do the pulling; they grow strong as they are exercised. In the meantime, also, the separate vertebræ are yielding to pressure. On one side they are growing thinner; on the other side, not being pressed upon, they grow thicker. The result is that some of the bones of the back will become wedge-shaped; and, sad to say, a back that has developed wedge-shaped vertebræ — vertebræ that have kept their wedge shape until they are hardened for life — can never hope to be straight again.

VERTEBRA SEEN FROM ABOVE

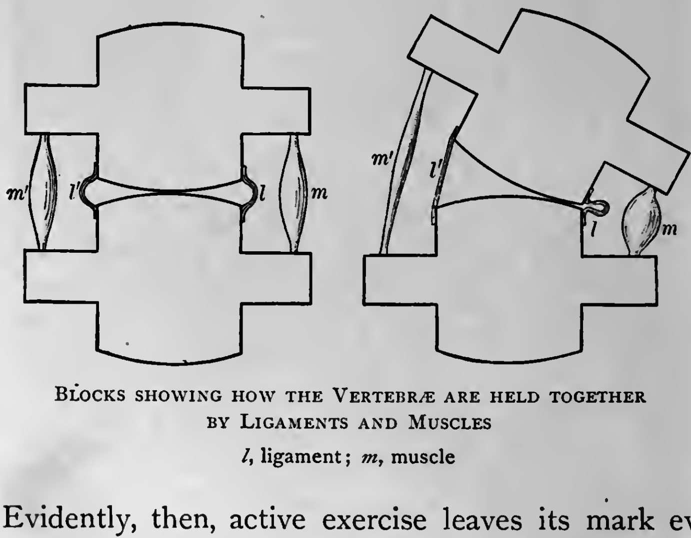
Bones Enlarged by Work. Certain other bones may, however, be changed by what they are compelled to do. To make them rougher and larger you must work the muscles which are fastened to these bones; work them hard; be persistent, and the result will come.

VERTEBRA SEEN FROM THE SIDE

WEDGE-SHAPED VERTEBRÆ

Pressure was too often on the same side

In studying human skeletons it is not difficult to point out the bones of such persons as did vigorous muscular work, by their heavier and rougher character, while the thin walls and fragile internal substance of other bones show that the muscles that moved them were paralyzed or wholly useless during life.



Blocks showing how the Vertebræ are held together by Ligaments and Muscles

l, ligament; *m*, muscle

Evidently, then, active exercise leaves its mark even on the bony part of the body. Thus, without making any close examination of our own separate bones, we may know, by the exercise we give them, what their prospects are year by year.

The Foot under Pressure. Nor are vertebræ the only bones to suffer under pressure. Think of the bondage of the feet, both in China and in other lands.

As I looked at the small, deformed feet of our friend, the Chinese lady, I knew what had happened to the bones that made up the bulk of the huge ankle above the shoe. No one saw this ankle. All we saw was

Chinese Shoes Two and a Half Inches Long

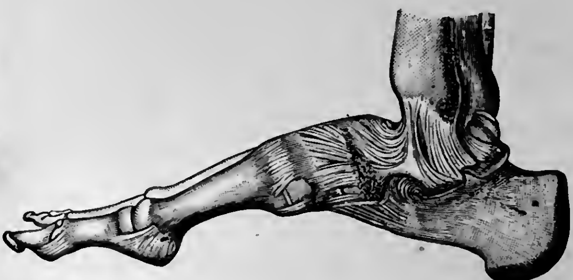
The huge ankle shows how deformed the foot really is

the dainty, handmade shoe, two and a half inches long, embroidered in silk of lovely shades, and made of cloth and silk with a leather sole. But we knew that within those shoes the toes were drawn in under the foot, the heel drawn forward to meet them. We knew that from early childhood those feet had been held in bondage by bandages, that muscles and tendons had been kept from growing, and that bones had taken strange new shapes of deformity. Fortunately for children in China,

THE BONES OF THE FOOT

the government now forbids foot-binding. And what about uncomfortable shoes for ourselves?

The Bones of the Foot. When you see your own bare foot to-night, compare its natural shape with the shape



BONES AND LIGAMENTS OF THE FOOT AND ANKLE

of fashionable shoes. Then consider the following facts and decide what the sensible course of action is:

1. Each foot is made up of twenty-six small bones.
2. These bones are joined to each other by ligaments and muscles.

3. If the arch of the foot is flattened, health is apt to suffer. Indeed, it is so serious a matter to be flat-footed that men with this handicap are refused admittance to the United States army. Test the condition of the arch of your own foot by dipping the bare sole lightly in water, then pressing it on blotting paper. The imprint made will show the flat or the arched instep. Those who stand still for hours every day should save the arch by resting the weight of the body first on one foot, then on the other. If you have any tendency to flat feet, help yourself by standing with toes turned inwards and, while in this position, rising as high as you can on your toes. Do this one hundred times twice a day, or rise and fall on the toes until the muscles are tired. The results will be satisfactory.

FOOTPRINTS

A, an arched foot; *B*, a flat foot

(After Schmidt)

A WOMAN'S FOOT DEFORMED BY FASHIONABLE SHOES

(After Schmidt)

4. No foot can exercise itself easily unless each muscle, bone, and ligament is allowed to move with freedom.

Rules for Foot Hygiene. The following are rules for foot hygiene:

1. Wear shoes with soles as broad as your foot is when you stand with no shoe on.

2. Do not lace shoes so snugly about the ankle that the pressure will interfere with the circulation of blood. Cold feet often come from tight shoes, tightly laced.

3. Let the heels of your shoes be broad and low.

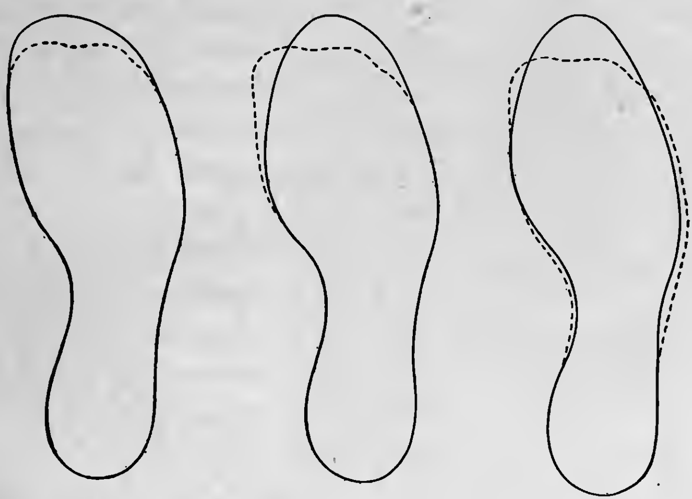
4. Never wear tight garters. They interfere with the movement of the blood through the blood vessels. Wear side garters. They do not bind the blood vessels.

5. Remember that tan shoes are rather better than black shoes for summer wear, because they do not keep the feet so warm.

6. Keep the feet dry and warm, but if possible avoid overheating them.

7. Be sure that your shoes are large enough to give your toes as well as your ankle a chance to move and to be useful when you walk.

Joints and their Ligaments. And what can be said about joints, the movable meeting place of the bones? By every twist that you can make, try to decide where your joints are and how each works. You will find that some work back and forth like a hinge, while others have the power to move back and forth and sidewise too. The different kinds of movement are



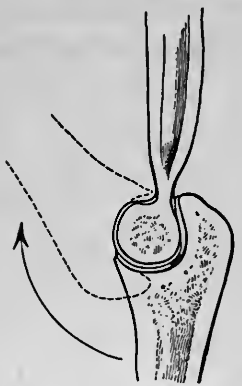
A *B* *C*

THE SHAPE OF THE FOOT AND THE SHAPE OF THE SHOE

Dotted lines show the natural shape of the foot; solid lines show the sole of the shoe. *A*, correct shape; *B*, the large toe is drawn in too far; *C*, the shoe is too narrow. If you wish a comfortable and a well-shaped shoe, get one that is wide enough, but longer than you need. This will give you the effect of having a slender foot

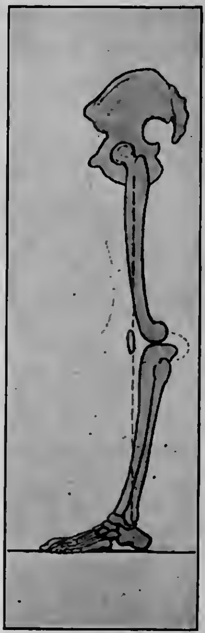
the result of different kinds of joints. Each is needed in its particular place.

The Hinge Joint. Begin with the hinge joint where your skull is joined to the upper end bone of the spine. This allows you to bend your head up and down, and nothing more. But just below, between the next two bones, is a joint of another sort. This allows you to turn your head from side to side. Thanks to the two joints acting as one, you can move your head in any direction. Elbow and knee, fingers and toes — all act on the plan of the hinge. Test them for yourself.



Cut through the Hinge Joint of the Elbow

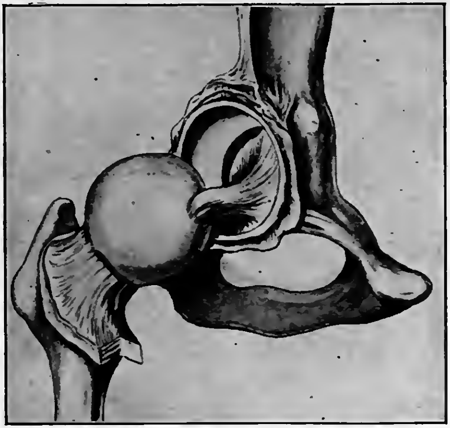
A Ball-and-Socket Joint. Whirl your arm round and round and know that you are using the most movable joint in the entire body. It is a so-called ball-and-socket joint. The hip is supplied with another of much the same kind. Here the socket (in the pelvic, or hip, bone) is shaped like a cup, and within it is the round head of the femur, or thigh bone.



Bones and Joints of the Leg

When we think of the work which the hip and the knee have to do for us, and of the strain we are ready to put on them at any moment, we understand why the hip and knee joints should be among the firmest and the strongest parts of the whole body.

Ligaments help make the joints. These bands of tissue are firm and white and tough, like tendons. Like tendons, too, they are slow to heal when torn. But they have nothing to do with muscles. Instead, they fasten bones to each other, while tendons fasten muscles to bones.



HIP JOINT DRAWN OPEN

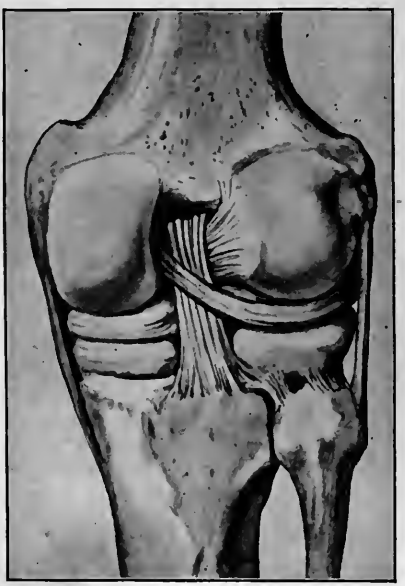
Notice the ligament which holds the ball in its socket

The knee is a wonderful structure of bones and ligaments. It is a great hinge joint supplied with ligaments which allow it to bend one way, but which absolutely forbid any bending in the opposite direction. If it were not for ligaments which hold the bones together in a definite relation, our knees would bend backwards and forwards with equal ease, and walking would be forever out of the question.

Two kinds of joints are thus seen to be most prominent in the body of man: (1) hinge; (2) ball-and-socket.

The Synovial Fluid. The ends of bones which form joints are covered with smooth and shiny cartilage, or gristle, to which ligaments are fastened. Also, within the joint itself, there is a small, delicate bag, holding a few drops of slippery liquid — synovial fluid. This fluid lubricates the joints and helps their smooth movement.

We have now learned that the ends of our bones are shaped to meet each other; that they are carefully fitted together; that tough ligaments hold the one to the other; and that muscles end in tendons which draw the bones in such directions as the joints allow. But bones move only when the heart beats. We study this subject next.



THE BACK OF THE KNEE JOINT
Notice the ligaments that hold the bones together

QUESTIONS

1. How do bones help muscles? 2. How do muscles and tendons help bones? 3. Describe the outside and the inside of a fresh bone. 4. What does a magnifying glass show about it? 5. What can a chemist do to bone? 6. What can a cook do with a bone? 7. What two important substances form bone? 8. Why do aged people need to be more careful than children? 9. Describe the different shapes bones may have and give the number of bones in the human body. 10. What is a vertebra? 11. How many vertebræ are there? 12. How are they held together? 13. What lies between the vertebræ to prevent jarring? 14. Explain how vertebræ may become wedge shaped, and tell what harm results.

15. How many bones are there in the foot? 16. How are they joined together? 17. Which is more desirable, the flat or the arched instep? 18. How can you decide which kind you have? 19. If you have a tendency to flat feet, how can you help save the arch? 20. Why should the feet be uncramped? 21. In buying shoes, what points should be kept in mind?

22. What fastens muscle to bone? 23. Describe how muscles help move a bone. 24. To what bones are those tendons fastened which belong to the muscle which forms the calf of the leg? 25. Is the contracting done in muscle or tendon? 26. Describe the joints which lie between the skull and the spine. 27. Where do we find important ball-and-socket joints? 28. What sort of joint is there at the knee? 29. What is the difference between a tendon and a ligament? 30. Name two kinds of joints. 31. Where do you find examples of each?

CHAPTER IV

THE HEART AT WORK

The Pulse. Let some one hold a watch while you and perhaps your friends test yourselves in various ways.

Stand with your finger on your pulse at the wrist, and when the person who holds the watch says, "Get ready — begin," let each one start to count the regular throb of the pulse which he feels under his finger. Let him keep on counting until, at the end of one minute, the timekeeper says, "Stop." You will then have your count.

COUNTING THE PULSE BEAT

If you are not excited, if you have not been exercising hard beforehand, if you have made no mistake in your counting, the number of beats which you feel will show what your regular, everyday pulse beat is. You have secured your standard for the standing position. You are ready for the next test.

Stand perfectly still and, while the timekeeper follows the time again, open and shut your hand as fast and as hard as you can for an entire minute. Then once more count your pulse. You may find that it has gained a trifle in the number of beats. This will depend on the vigor with which you have worked the muscles of your hand. But the muscles there are small, and you will not get much result in the way of a more rapid beat.

He counts both Pulse Beat and Heart Beat

Turn, therefore, to the leg muscles. Use them vigorously. Run up one flight of stairs and back, and at once count the pulse again. You will find a marked change. From eighty or over at the start, you have probably increased the count to one hundred and twenty or more.

The Pulse Beat and the Heart Beat. In addition to the above tests make one more. While the fingers of your left hand are feeling the pulse in your right wrist, place your right hand over your heart. You will discover that the pulse beat and the heart beat occur at the same instant. And now, if you were not uncomfortably out of breath after the run up one flight, try two flights and notice that the number of beats has increased both at the wrist and at the heart. You have proved for yourself that the pulse beat may be depended on to show the rate of the heart beat.

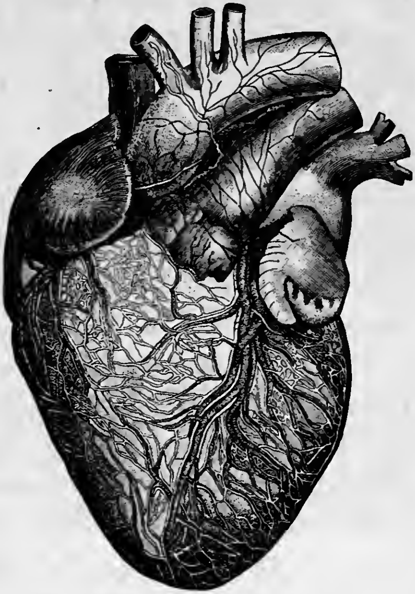
The Effect of Exercise on the Heart. The following table shows what such exercise did for a small class of children in a New York school. The letters of the alphabet stand for the names of the children.

TESTS SHOWING EFFECTS OF EXERCISE ON THE HEART BEAT PER MINUTE

	Normal Pulse	After Short, Quick Run
A	85	130
B	83	142
C	71	113
D	85	95
E	85	113
F	88	120
G	83	95

Each child was tested again within a minute after the run, and already the pulse was found to be beating more slowly. This rapid return to the normal beat is the sign of a healthy heart.

Test yourself in other ways. Count your pulse when you get up rested in the morning and when you go to bed tired at night. Count it before and after your cold bath in the morning. Count it before and after any kind of exercise that interests you. For example, run to school one morning, walk another morning, and compare the results of both with your standard. Compare the number of beats of the heart that has done hard work with those of the heart that has done light work, and see what gives your heart the most exercise. Through all this you learn what the power of your own heart is.



THE HEART AND ITS GREAT BLOOD VESSELS

We are well or ill, we live or die, by the work it does or fails to do

Already you know that exercise makes the heart beat faster, and that the larger the muscles are and the harder the work they do — running, for example — the more exercise will the heart have. You have also learned that the pulse may always be trusted to tell important facts about the action of the heart.

What the Pulse Beat Proves. It is for this last reason that a doctor feels the pulse of his patient. By the regular or the irregular beat of that pulse, by the way it hurries or by the way it drags, he is guided in his judgment as to what the condition of the patient is and what ought to be done to help him. The heart, indeed, is one of the vital centers of our activities. We are well or ill, we live or die, through the work which it does or fails to do. Yet ignorant persons often give it either too much or too little exercise. Many frail women fear to take exercise lest they overtax the heart, while bicycle riders, and others who exert themselves beyond reason, often overtax the heart until it is injured for life. This is also true of boys who run long or hard races before their hearts have been trained for such violent exercise.

The Heart Muscle. It seems that the heart is a strong hollow muscle about as large as the fist of the one for whom it works, and that even when it is not overtaxed it does more work than any other muscle in the body. It lies under the ribs, between the two halves of the lungs, and keeps up its beating from birth to death. Even though it is so constantly active, still, like every other muscle, exercise gives it strength, while lack of exercise leaves it weak.

In training this important muscle let us remember that most human beings have sound hearts that need to be treated in a reasonable way.

Overtaxing the Heart. A neighbor of ours had taken no special exercise all winter, but when spring came he began abruptly by playing one set of tennis after another without resting. The result was that for many days and nights his heart kept up a rapid beating. For three weeks, indeed, it refused to come down to normal, and during this time the man dared take no exercise whatever. He knew it would be unsafe.

If he had been careful to begin his tennis-playing gradually, increasing the amount from day to day, he would have done better work, would have spared his heart the overstrain, and would have saved himself weeks of weariness.

At the Critical Moment

Training Heart and Muscles Together. Watch those who race to catch a car. By the way they breathe you may know what the heart is doing. You will also be able to tell which of the running men and women have trained their hearts for sudden sprints of violent work, and which are pressing untrained hearts into unusual service. College students often run by the mile across the town and out into the country. They are training not only the many muscles of their legs but also the one muscle of the heart and their breathing apparatus as well. They wish to train their leg muscles, while at the same time they secure for themselves hearts and lungs that will help each other and be useful as long as their legs are able to keep up the running.

A doctor whom I know speaks of a man whom he himself trained. He says:

> When I took charge of him the man could not run as far as from here to the door without fainting. He simply had a muscularly weak heart, excited by nervous shock and overwork, worry, deficient nutrition, and lack of sleep. I first discovered that there was no organic disease. Nothing but plain building up of muscle was needed. Then I went to work and started to build up that muscle. I would have him run a few steps and then lie down three minutes, then run a few steps more and lie down. I stood by, keeping track of his heart, not allowing him to do enough work to send it above one hundred and not letting him run again until it got back to normal. I kept him at it half an hour three times a day, from day to day increasing the doses; that is, I stuck to the medicine, but I gave very small doses, — doses suited to the strength of heart he then had. In three months that man could run eight miles an hour with great ease and comfort. Since then he has not known that he has a heart.

Overstretching the Heart. This doctor also speaks of a friend of his who ran up eight flights of stairs because of a fire, and so overstrained his heart that it has never been right since.

This shows that when the heart has done what it comfortably can, and then has to do still more work and keep it up, it stretches too much for its own good.

And worse still, if stretched badly enough, it stays stretched. This is part of the trouble with the overworked heart of the bicycle rider. Athletic trainers understand these facts thoroughly. It is therefore as much for the sake of the muscle of the heart as for the benefit of leg muscles that they insist that only those who have been trained for the contests shall be allowed to compete in athletic games. Otherwise the untrained person might faint in the midst of the sport, harming himself and frightening everybody.

The safe rule is to give the heart all the exercise it can comfortably take at one time, and to increase the amount as fast as its power increases.

As a rule, the actual size of the normal heart is large or small according to the work it has had to do. Animals kept in cages and captivity have been examined after death, and their hearts have been seen to be smaller than the average heart of wild animals of the same kind. In proportion to his size, the heart of a stag is about twice as large as that of a pig. The reason is plain. The stag lives by exercise which makes the heart work; the pig, except in the wild state or in pasture, seldom takes any unusual exercise.

Heart Development. Provided one does not undertake too much, nothing is better for heart development than exercise which calls for endurance. A quick run for a minute, or a brisk jog trot lasting five minutes, is as good as anything that can be devised. Run a little as you go to school in the morning, then walk a little. Run only as much as you can quickly recover from. By your pulse beat and by the way you keep your breath or lose it, you will know what you may do. Begin with little exercise, for you are going to make steady gain whatever your starting point is, and you gain most by going moderately at first.

Throughout his entire life the person who has a well-developed heart will also have more vigor, more power to endure, more courage than he otherwise would have. The result is worth working for.

Harvey's Discovery. This we all know now, but three hundred years ago even learned men were ignorant both about the heart and about its activities. Then came Harvey's great discovery. In 1616 we find William Harvey, an English physician, lecturing in London. He was only thirty-eight years old, and already his medical reputation was very great. When he died, at the age of seventy-nine, he had changed certain beliefs of the human race. Nor did this come about by accident. During his active life, whenever he had the opportunity for it, — whether with men or with animals, whether with those who were well or ill, alive or dead, — he studied the body and gave special attention to the action of the heart and to any connection which it might have with the blood supply.

Arterial and Venous Blood. In the case of wounded animals, at different times he laid his hand on the heart and noticed that with each throb the blood left the wound with a spurt, and he saw that blood which spurted in jets from a wound was always of the bright-red kind. This is now known as arterial blood.

Then too he observed wounds that bled in a different way. The blood simply poured out in a quiet, dark-purplish stream, and there was no sudden increase of flow with the heart beat. This is venous blood. He found that the same was true for wounds in man and beast alike — that bright blood came in jets, while dark blood came in a quiet stream. He saw too that whenever the heart beat slowly the pulse at the wrist was slow too.

These important observations, added to many experiments which he himself made, drew Harvey's thoughts more and more to questions about circulation. It then occurred to him that the heart might be a special machine for pumping bright-colored blood out into the arteries, and the thought of such a possibility was exciting even to himself, for no one had suspected this before.

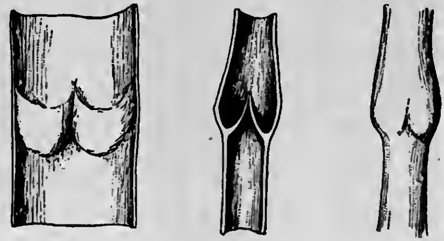
Arteries and Veins. Through yet other experiments and constant thought on the subject, his surmises gradually changed to convictions. He became very sure that every pulse beat in the artery at the wrist meant that the heart had pumped a fresh supply of blood into the large artery — the aorta — which is joined directly to it, and that the elastic tubes had expanded throughout their entire length to make room for the blood. He knew, as we do, that the largest arteries are buried deeper in the body than the veins, and that only at certain spots do they come near enough to the surface to allow us to feel the effect of the heart beat. He noticed that there is never any throb in a vein, and this strengthened his conviction that no vein ever receives blood directly from the throbbing heart.

The Work of the Heart. By traveling the road which he took, we have come upon Harvey's first great discovery: *the heart pumps blood into the arteries.*

The scientific world was greatly excited over this announcement. But Harvey himself went quietly on with his investigations. He used his own methods of measurement, which are different from ours. But the amount of blood in the human body was the same then as now, and it was this blood supply that Harvey studied and that we also are studying. He saw that the heart pumps by contracting and expanding; that the average human body holds about six quarts of blood; that the heart sends about half a tumblerful of blood into the aorta every time it contracts; and that, since the heart beats about seventy times a minute, an enormous quantity of blood must be squeezed out of it during each half hour.

He did some multiplying, and decided that if the heart sends out over two thousand tumblerfuls of blood every hour, and if the body holds no more than twenty-four tumblerfuls, — that is, six quarts, — the enormous supply must be explained somehow. We of course know that the same blood is being pumped over and over again, and that this explains the quantity. But Harvey did not know this. He asked where it all came from.

One sign after another led him to suspect that the veins might supply the explanation. He therefore tested both veins and arteries, as we ourselves may do.



A *B* *C*

Pocket Valves in the Veins

A shows a vein slit lengthwise and laid open; *B* shows a vein cut through lengthwise; *C* shows how a vein looks from the outside when its valves are filled with blood

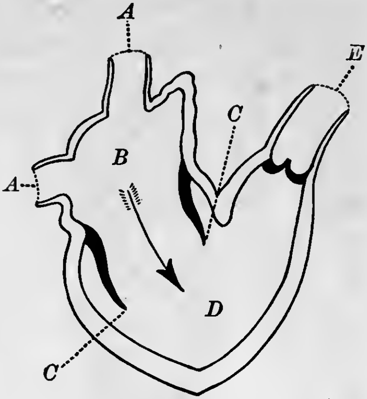
The Use of Valves in the Veins. Draw up your sleeve, swing your arm round your head once or twice, let it hang by your side for a minute, and you will notice that some of the blood vessels appear as dark lines under the skin. Stroke these lines down towards the wrist. They are veins, and the little bunches which stand out show where the valves have caught the blood. These valves are on the inside lining of every vein, and they always open towards the heart. When blood in a vein flows towards the heart, the valves lie flat and smooth against the lining, and you would not suspect their presence. But try to drive that blood in the vein away from the heart, and quickly every valve is lifted so that it stands out like a little pouch and blocks the passage of the blood backwards. The structure of the veins, therefore, helped Harvey on towards his next discovery.

A HANDKERCHIEF AND A STICK TO COMPRESS AN ARTERY

As the stick is turned the bandage is pulled tighter

Experiments with the Blood Flow. Uncover your left arm and squeeze it with your right hand, stroking the arm hard upward towards the elbow to hasten the blood out of the veins. Now, as quickly as you can, tie a bandage tight about the arm just above the elbow. Within a few seconds notice how you feel, and notice the color of your hand. It is pale and grows cold.

Arteries are buried deep. Veins are near the surface. Your bandage is therefore checking the flow in both sets of blood vessels, and because no blood can get into the forearm, the color of it stays about as it was after you had tied the bandage. Above the elbow, however, you feel a throbbing, because the blood in the arteries is held back by the dam of the bandage. Loosen the bandage a little. You have now lifted the pressure from the arteries, and blood hurries towards the hand. But the veins are under pressure still; notice what is happening. Blood is entering through the arteries; it cannot escape through the veins because of the pressure of the bandage. As a result the hand grows red and swollen from its unusual supply. Release the bandage entirely, and in almost no time the veins will have relieved themselves. Blood is once more streaming upwards.



THE RIGHT AURICLE AND VENTRICLE

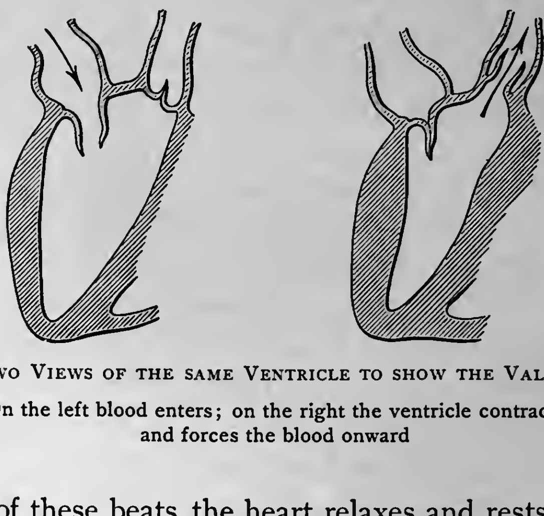
A, vein that brings blood to the auricle; *B*, auricle; *C*, valves that are forced open by the blood as it passes into the ventricle; *D*, ventricle; *E*, tube through which blood goes to the lungs to be purified

Such experiments as these and others led Harvey to his second announcement. He declared to his astonished friends that *the heart receives its entire blood supply from the veins.*

The Structure of the Heart. To complete this account, turn to the heart again and remember the following facts about it:

1. The heart is a powerful muscle. It does its work by contracting and relaxing. When it relaxes,

the blood pours into it through an open valve; when it contracts, it forces about half a teacup of blood at a time onward and out of it through another open valve. Each time it contracts, its apex touches the wall of the chest near the fifth rib. This is what we feel and call the heart beat. After



TWO VIEWS OF THE SAME VENTRICLE TO SHOW THE VALVES

On the left blood enters; on the right the ventricle contracts and forces the blood onward

each of these beats, the heart relaxes and rests while more blood pours into it. We see from this that the heart rests about half the time.

2. The heart is made up of two halves, and the wall of muscle between these separate halves is so firmly closed that after birth, and after the heart is in good working order, not a drop of blood ever passes through it from one side to the other.

3. Each half of the heart has two divisions, the smaller called the auricle, the larger called the ventricle.

4. Each auricle and each ventricle has its own opening, its own tube for blood, and its own valves to prevent the blood from running the wrong way.

5. The auricle in each half of the heart always receives the blood and sends it into its own ventricle.

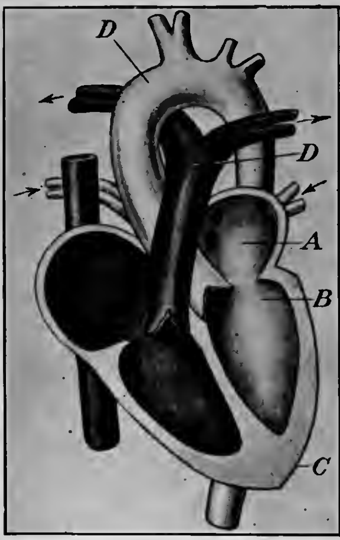
6. Each ventricle receives blood from its own auricle and sends it off to its own district of the body.

7. Tubes which carry blood from the heart are called arteries. Tubes which carry blood to the heart are called veins.

8. The right side of the heart receives impure blood from the body and sends it to the lungs to be purified. This is called the pulmonary circulation. The left side of the heart receives the cleaned, purified blood from the lungs and sends it off through a large artery, the aorta, for use everywhere in the body. This is called the systemic circulation.

The Double Work of the Heart. At this point we reach a most interesting fact about the process of circulation, yet it may be given in a few easy words. *One side of the heart always receives blood from the body and sends it to the lungs; the other side of the heart always receives blood from the lungs and sends it through the body.*

We see, then, that one side deals with pure blood alone, for all that comes to it is fresh from the lungs and is sent onward in the same condition; while the other side deals with impure blood alone, for all that comes to it has been used by the body and in this condition goes direct to the lungs to be purified.



THE FOUR CAVITIES OF THE HEART

A, auricle; *B*, ventricle; *C*, outline of the heart; *D*, *D*, blood vessels

The dark side receives impure blood from the body and sends it to the lungs; the light side receives pure blood from the lungs and sends it to the body

Thus *the entire blood supply of the body, on each journey round, passes through both sides of the heart and through the lungs before it goes back to nourish the body.* This was Harvey's great discovery about the circulation of the blood. Even for him, however, there was still a mystery. "What becomes of the blood between times?" he asked. "How does it get from the arteries to the veins for its journey back to the heart?"

Capillary Connections. Harvey himself was not able to answer these questions, for microscopes had not yet been invented, and nothing but the microscope can reveal the close network of capillary connections which carries the blood across from arteries to veins for the return trip to the heart.

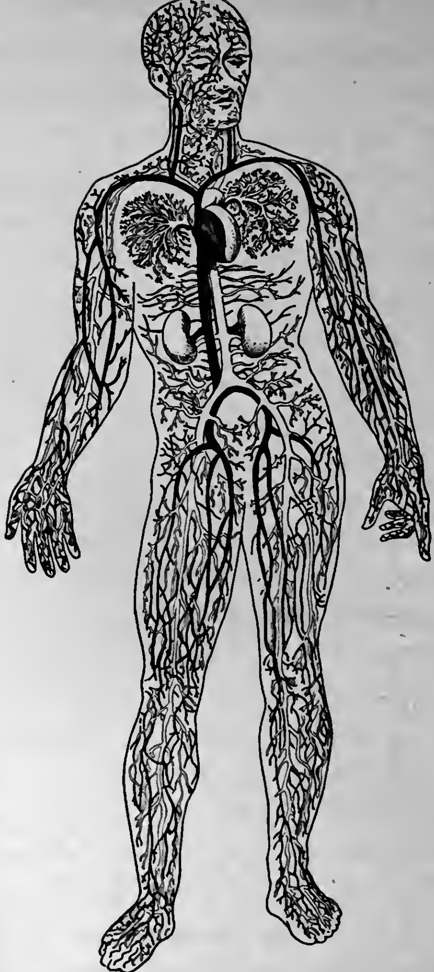
The Circulatory System. But when the microscope came with its revelations, doubts and questions were cleared away. Instead of blood spread about everywhere among the muscles, under the skin, between the arteries and the veins, there was found to be no blood anywhere outside of the tubes. Moreover, each drop of blood was found to be a part of the ceaseless stream which flows through tubes that divide and subdivide until they are too small for the unaided eye to see, and then unite and continue to unite until they are again large enough to be seen. This is well called the circulatory system, for round and round the blood goes in endless circulation; and when the circulating stops, we stop living.

The following table shows how long it takes blood to make the entire circuit of the body in different animals.[1]

Horse	25 seconds
Full-grown man	23 seconds
Child of fourteen	18 seconds
Child of three	15 seconds

Thus swiftly does the blood within us stream from the heart through arteries, capillaries, and veins, back

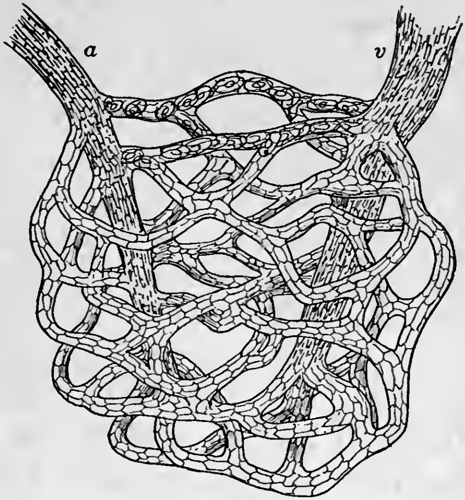
[1] A trained person pricks some harmless chemical into a vein on one side of the body, then examines blood from the corresponding vein on the opposite side of the body until the same chemical appears there. By this he learns how long it takes blood to make the circuit.



Veins and Arteries

Black tubes represent veins through which impure blood goes to the right side of the heart from all parts of the body; light-colored tubes represent arteries through which pure blood from the left side of the heart goes to all parts of the body. Notice that the large tubes of each kind lie near one another to the heart again. And the sight of its progress through the tubes must have thrilled those who watched it for the first time.

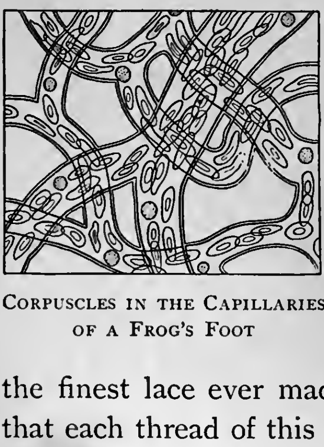
Corpuscles in the Capillaries. One early scientist, who lived over two hundred years ago, looked through his crude microscope at the tail of a tadpole. He had already discovered the corpuscles of the blood, which we shall study soon, and he saw these separate "blood globules," as he called them, moving after each other in single file through the narrowest of the tubes. Sometimes they moved in faster, sometimes in slower, procession; and sometimes they were even bent over and pressed out of shape as they were forced through the narrowest places. He grew enthusiastic over what he saw, and wrote a glowing account of it.



UNION OF ARTERIES AND VEINS

a, artery; *v*, vein. A network of capillaries joins them

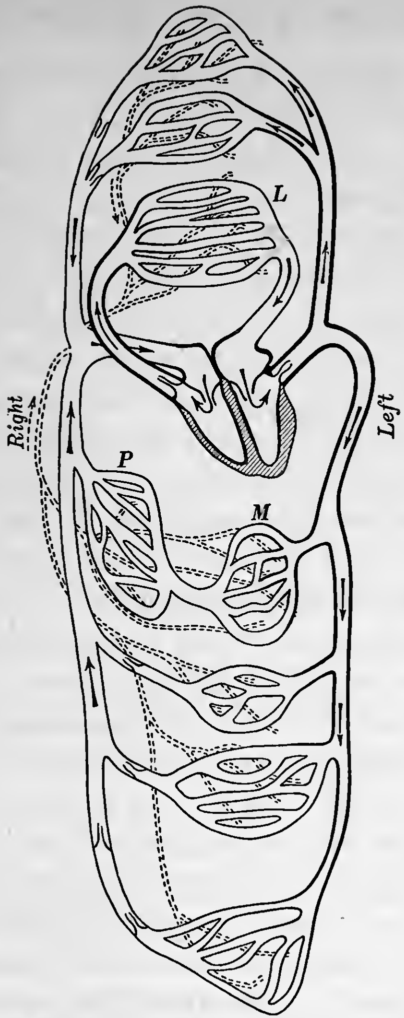
The motion of the blood in these tadpoles exceeds all the rest of small animals and fish I have ever seen; nay this pleasure has ofttimes been so recreating to me that I do not believe that all the pleasures of fountains and waterworks, either natural or made by art, could have pleased my sight so well. And now at last I spied a small artery, that notwithstanding it is so small that, I judge, but one small red globule of blood could pass through it, . . . yet, what was most remarkable was to see the manifold small arteries that came forth from the great one, and which were spread into several branches, and turning, came into one again, and were reunited, that at last they did pour out the blood again into the great vein; this last was a sight that would amaze any eye that was greedy of knowledge.



CORPUSCLES IN THE CAPILLARIES OF A FROG'S FOOT

From what we saw, and from what we may see for ourselves with the microscope, we find it easy to understand that every gash made in the flesh of the body cuts through a mesh of lacework more delicate than the finest lace ever made by the hand of man; we see that each thread of this lace is a tube doing faithful duty in carrying blood to remote regions of the body; we see that everywhere there is blood simply because everywhere there is the same intricate interlacing of these marvelous tubes. Their name *capillary* means "hairlike." Yet the microscope shows how much smaller they sometimes are than any human hair, however soft and fine.

By careful calculation it has been found that fifteen hundred capillaries would have to be laid side by side to cover a surface an inch wide.



The Heart with its System of Tubes

Arrows show the direction in which the blood flows. Follow its course from the body into the right side of the heart; from there to the lungs; thence to the left side of the heart and out to the body again. Each cluster of tubes shows in a rough way where some organ of the body is located

The Blood Supply. As a rule, the amount of blood which is inclosed in the system of tubes which includes heart, arteries, capillaries, and veins is about one thirteenth the weight of the person. We may then calculate our own supply of blood by our own weight, and decide just how much it takes to keep our blood vessels and heart as full as they need to be. The truth, however, is that being elastic they could at any time hold more than is now in them; and that at any time also they could get along very well with less than they now carry.

In former times men sometimes died for no other reason than that they lost so much blood from wounds of one sort or another that the sides of veins and capillaries collapsed, and the heart had to stop work because there was too little blood left in the body to be pumped round. It was therefore a great discovery when men found that the heart is quite as willing to pump warm salt water out into arteries and capillaries as to send warm blood to the same places. Nowadays, therefore, when a man is losing much blood through an operation or through an accidental wound, a surgeon, working as fast as he can, pumps salt water into the veins to replace the blood. This water is carried on round the circuit as swiftly as if it were the richest blood, the pumping of the heart continues, and a life is saved. It keeps the veins filled and the heart in action for a season, while the proper sort of blood is being manufactured by the body itself.

Exercise and the Blood Supply. In a way we might suppose that the blood of the body is spread out in equal quantities everywhere, being regulated by the size of the tubes which carry it about. The truth is, however, that *exercise regulates the amount of blood which goes here or there;* that is, what we do always settles the question as to where the blood shall go. For the normal healthy person this law never varies. It may be stated in a few words: *that part of the body which is exercised the most gets the most blood; that part which is exercised the least gets the least blood.*

The sixth chapter shows what it means to the body when this law is remembered or forgotten, and what the nature of the blood is, that it should be so greatly needed here and there. But before taking up that subject, we turn to the study of heart action and nicotine.

QUESTIONS

1. How may you get the standard of your heart beat? 2. What shows the rate of heart beat, and how can you increase that rate? 3. Which increases heart beat more, exercise of large or of small muscles? 4. Why does a doctor feel the pulse of his patient? 5. Give two opposite mistakes often made in exercising the heart. 6. Describe the heart — its structure, position, and size. 7. When does it work? 8. How may the heart of a tennis player show that it is overtaxed? 9. How should one begin tennis-playing in the spring? 10. Mention

some way by which muscles, heart, and breathing apparatus can all be trained at the same time. **11.** What advantage is there in having a well-trained heart?

12. Who was William Harvey? **13.** What did he notice about the flow of blood from different wounds? **14.** What was Harvey's first great discovery? **15.** Give some facts that led him to this discovery. **16.** How many quarts of blood are there in the body? **17.** How much blood does the heart send out each time it contracts? **18.** How often does it contract each minute? **19.** What are the pockets in the veins? **20.** Which are deeper in the body, arteries or veins? **21.** What does the experiment with the bandage above the elbow prove? **22.** What was Harvey's second discovery? **23.** What can you say about the two halves of the heart? **24.** What is the work of the auricle? the ventricle? the arteries? the veins? **25.** What is the aorta? **26.** Which side of the heart receives impure blood from the body and sends it to the lungs to be purified? **27.** Which side receives pure blood from the lungs and sends it to the whole body to be used?

28. How long does it take blood to make the circuit of the body for a man? for a child of fourteen? **29.** Describe the circuit of the blood from the veins back to the veins. **30.** How does the blood get from the arteries to the veins for its return journey to the heart? **31.** When you cut yourself and blood flows, what have you actually done? **32.** What does *capillary* mean? **33.** What can you say about the amount of blood which the blood vessels may hold? **34.** In what way is warm salt water sometimes useful in blood vessels? **35.** What connection is there between exercise and the amount of blood sent to different parts of the body? **36.** Give this law of exercise.

CHAPTER V

NICOTINE AND THE SPHYGMOGRAPH

Tests with the Sphygmograph. In some tests which he was making, Dr. McKeever[1] enlisted the help of over one hundred boys. Their ages ranged from twelve to twenty years, and they all smoked. Indeed it was just because they smoked that Dr. McKeever was making his tests. He wished to see for himself what tobacco does for boys. If it helps them either in body or in mind, he intended to pass the fact on for the benefit of other boys.

In carrying on his investigations Dr. McKeever used the sphygmograph. This machine has a clockwork contrivance which moves a strip of smoked paper on which a needle records the heart beat. It is fastened to the wrist directly over the artery which passes that way, and as the artery throbs with the beating of the heart, the needle of the sphygmograph traces its way across the smoked paper and leaves its scientifically exact record there, in black and white. The illustration on the next page shows the making of a record.

[1] Dr. William A. McKeever, Professor of Child Welfare, The University of Kansas.

The boys were interested in the way the machine worked and in what it told about their heart action before and after smoking.

General Effects of Smoking. The records were taken at different times during the year, and each was slightly different from all the others, just as the handwriting

THE SPHYGMOGRAPH ON A WRIST, AND THE RECORD IT IS MAKING

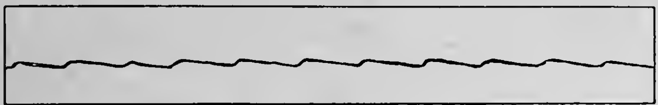
of one person always differs from that of another. On the whole, however, the various reports of the sphygmograph explained two apparently contradictory facts, both of which are perfectly well known:

1. The smoker says he feels better and is able to think faster and to work harder just after smoking than before the smoking.

2. Athletic coaches say tobacco prevents success. They therefore prohibit its use by their men.

It is as if one honest man said, "Smoking does me good," while another man, equally honest, says positively, "Smoking does you harm."

To reconcile these differences we turn to the diagrams borrowed from Dr. McKeever's record. Notice that one of these shows the heart beat of a tired young woman. She did not smoke, but she was on the verge of nervous prostration. Compare this with the record



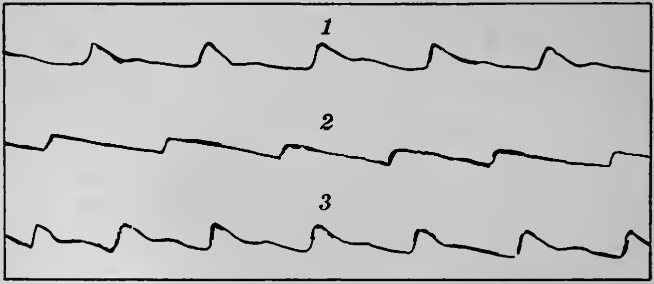
SPHYGMOGRAPH RECORD OF THE HEART BEAT OF A YOUNG WOMAN ON THE VERGE OF NERVOUS PROSTRATION

The young woman does not smoke. (From Dr. McKeever)

of the vigorous young fellow of nineteen who did not smoke. It shows the kind of work a healthy boy's healthy heart should do for him. (See p. 76.)

Compare both these records with the wave lines in the third diagram — the one on page 77. See that first flattened-out report (1), taken before the smoking began. It is quite like the heart beat of the worn-out young woman — faint, weak, lifeless. No wonder the fellow felt dull!

Effect of Smoking on the Heart. Study the next report from the same person. See the beat bound upward when the smoking begins — stronger, faster, more vigorous. Fresh blood is being sent to every part of the body. The brain feels it first and becomes more active. The smoker says he "feels good" — and no wonder. Not brain alone, but muscles and liver, stomach and lungs and kidneys, are now getting better blood faster and in larger quantity. Even the farthest-off, smallest

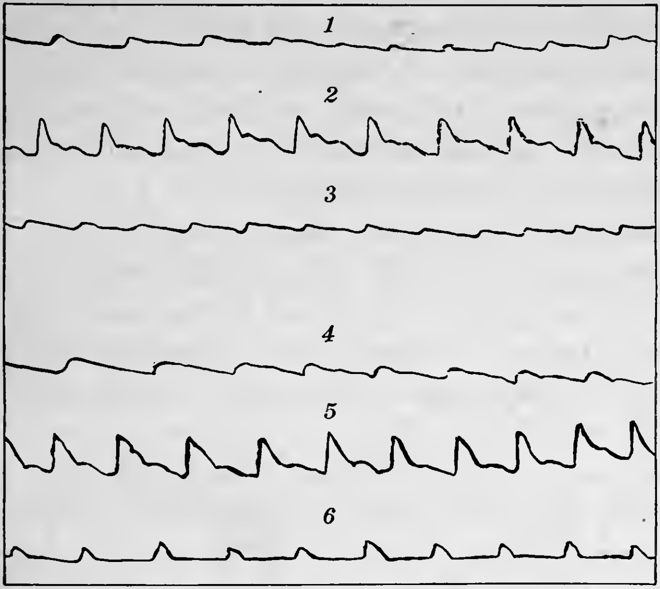


SPHYGMOGRAPH RECORDS OF THE NORMAL HEART

1, tracing for a vigorous fellow of nineteen; does not smoke. 2, healthy heart beat; a calm temperament; does not smoke. 3, heart tracing for a healthy young woman; does not smoke. (From Dr. McKeever)

capillary is stretched out a little larger, and more blood than usual hurries through it for a few minutes.

But this flush time is soon over. Fifteen minutes have passed. The sphygmograph has not been taken from the wrist; it is still making records. And now see what has happened. All the splendid vigor has faded out. Once again the heart beats almost at dead level. Brain cells lose their activity; muscles and liver, stomach, lungs, and kidneys, have to do the best they can with the slow-moving blood. It brings short rations of food to cells that cry out for nourishment. But, sad to say, the slow-pumping heart will stay in charge of the



SPHYGMOGRAPH RECORDS OF THE HEART BEAT OF TWO DIFFERENT PERSONS

1, 2, 3, tracings made by the heart of a young man of nineteen: 1, before smoking; 2, while smoking; 3, after smoking. He began to smoke cigarettes at fifteen. 4, 5, 6, tracings made by the heart of a young man of twenty: 4, before smoking; 5, while smoking; 6, after smoking. Began smoking at thirteen; now uses a strong pipe. (From Dr. McKeever)

slow-moving blood until the next cigarette is smoked. Then it will jump into quick action again for a few minutes.

The Tobacco Heart. This is why a smoker must often use fifty and sixty cigarettes a day to keep his heart up to the mark. This is how a healthy heart gets turned into a weakened heart. This is why the steady smoker often fails where he wishes to succeed. And the real reason for all this is the double character of tobacco; it is a stimulant, and it is also a narcotic poison. The smoker craves the stimulation; in addition he receives the poison of nicotine.

How Nicotine gets to the Heart. When a man lights his cigarette, the woody fiber of the burning tobacco turns to smoke and ashes, and at the same time the nicotine turns into vapor. If now the man draws the smoke into his lungs, the vaporized nicotine goes with it. But after reaching the lungs they separate. The smoke stays on all the delicate tissues of the lung cells, which is bad enough, but the vapor of the nicotine is not hindered by any tissues. Instead it passes directly through the tissue of the lung cells, enters the blood stream, and is whirled to the heart by the straightest road possible.

Effect of Nicotine on the Heart. At the moment it arrives, the sphygmograph shows what the poisoned whip has done. It has lashed the heart to vigorous action — not to last long, however, for soon the same sphygmograph shows that the vigor has gone, and that the permanent condition grows worse rather than better.

The United States army gives proof of this. At an examination for the military school at West Point, one quarter of the young men had to be refused admittance because they brought upon themselves the condition of "tobacco heart" from cigarette smoking.

At another time a set of 412 boys wished to enter the naval school at Annapolis. They were examined by an officer in Peoria, Illinois, and all but 14 were turned away. As was said by the examiner, "Of the 398 rejections, the greater number were on account of weak hearts, and in the majority of cases this was caused by cigarette smoking."

Dr. Seaver's Tests. In 1897, at Yale University, when Dr. Seaver made his thorough study of the matter, he found that out of every 100 students who ranked highest, 5 were smokers, 95 nonsmokers. Among the rest of the students at that time, 60 out of every 100 smoked. He also found that, on the average, those who did not smoke gained more in height and weight and girth of chest than those who smoked.

Remember that these Yale students were still in the growing time of life; recall the facts of the last chapter; then imagine what it means to have a young and growing heart attacked over and over again, day in and day out, for weeks and months and years, by a poison that does its worst work with the heart itself. It seems as if no harm to the heart could be much more serious.

Army officers and doctors declare that he who is in the habit of using cigarettes should be careful not to do anything that will call for sudden, or violent, or vigorous use of muscles and heart. Although he may still be able to run as fast and to jump as high as his friend or his schoolmate who does not smoke, yet the probability is that he has the sort of heart that the army refuses to accept — the heart that no soldier can afford to own. And the man who is afflicted in this way cannot expect to excel on the athletic field.

In this connection it is interesting to know what the leading trainers of the country say about the use of tobacco.

Mr. McBride, once captain of the Yale football team, wrote:

> It is absolutely necessary for a college or school athlete who is striving to win a place on any team to have endurance; especially is this true in rowing and football. This can be accomplished to the greatest degree only by abstaining from the use of tobacco and alcoholic drinks while in training for said team.

Mr. Edwards, once captain of the Princeton football team, wrote:

> A man who is using tobacco and alcohol contrary to orders during the season is easily detected, and is dropped from the squad.

Mr. A. A. Stagg of The University of Chicago wrote:

> We have never had a really successful long-distance runner at The University of Chicago who was a smoker. In football, as in other

endurance tests, there is no question at all in my mind that the man who smokes does not come up to the level of the general run of nonsmokers.

For thirty years "Mike" Donovan was the athletic director of the New York Athletic Club, and from his wide experience he writes:

> Any boy who smokes can never hope to succeed in any line of endeavor, as smoking weakens the heart and lungs, ruins the stomach, and affects the entire nervous system. If a boy or a young man expects to amount to anything in athletics, he must let smoking and all kinds of liquor alone. They are rank poison to his athletic ambitions.

It would seem then that, for the sake of the heart and for the sake of success, cigarettes must be put aside. And now we return to the subject of circulation and the blood stream.

QUESTIONS

1. Describe Dr. McKeever's tests with the sphygmograph. 2. Describe the sphygmograph. 3. Give the two opposite statements made by smokers and by athletic coaches. 4. Show by the chart why the smoker feels so well just after smoking. 5. What happens to the heart soon after the smoking stops? 6. Why are many cigarettes necessary to make one feel vigorous? 7. What objection is there to these cigarettes? 8. How does nicotine get to the heart? 9. What effect does it have? 10. Why are so many boys rejected by the medical examiners for West Point and Annapolis? 11. Describe Dr. Seaver's tests with college boys. 12. What did he discover about their scholarship? about their height, weight, and girth of chest? 13. If a person is in the habit of using cigarettes, what kinds of exercise must he avoid? 14. What have some of the athletic directors and football men said about the effect of tobacco on health?

CHAPTER VI

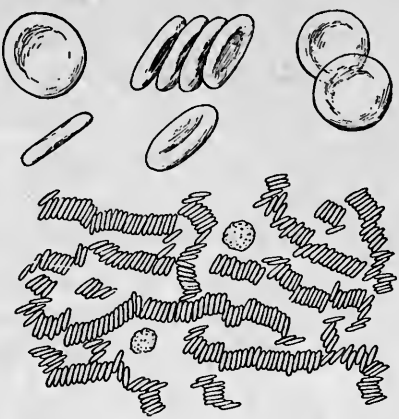
BLOOD AND LYMPH INSIDE AND OUTSIDE THE TUBES

Blood Examination. Tie a string round the last joint of a finger of your left hand. Bend the tied finger over, to increase the pressure of the blood in its capillaries. Take the finest needle you have, hold it in a candle or a lamp flame for a moment to rid it of microbes, then stick the point of it quickly into the dark-red end of the finger. You will tear open several capillaries smaller than the needle, and a good-sized drop will ooze through. Nevertheless you will barely feel the prick. Have a piece of clean glass ready and jostle the drop of blood down upon it. Raise the glass, hold it over something white, and notice the color. You will see that it has a yellow tinge. Leave it on the glass for five or six

PREPARED TO DRAW A DROP OF BLOOD

minutes, then look at it again. You will find it turned to jelly. Set a tumbler over it and let it remain undisturbed for half an hour or so. At the end of that time you will see a bit of red substance floating in a small drop of liquid which is almost colorless.

Coagulation. Look back at the finger you pricked, and if you did not wipe it off clean after you did the pricking, you will see that there, too, a remnant of the blood has hardened round the edges of the tiny wound. This hardening of part of the blood is called coagulation. It will remind you of the statement so often made, that the best healer for a wound is the blood which oozes through it. Healing goes on beneath it.



CORPUSCLES SEEN BY THE AID OF A MICROSCOPE

A few red ones are highly magnified. Those that are less magnified show how corpuscles stick together after blood is drawn from the body. Two white corpuscles are given

Blood under the Microscope. If we could add the use of a microscope to our experiments, we would draw a second drop of blood, and we should learn a number of important facts about its composition. We should then recognize it as a liquid with multitudes of small red and white objects floating in it. Blood is indeed a mixture of three things:

1. *Red objects, called red corpuscles*, which give the blood its color. There are millions of these in each drop of healthy blood. Imagine then their size! Each is round and flat, with a concave center, and these microscopic disks are the important oxygen carriers of the body. They never leave the blood tubes unless these tubes themselves are crushed, or cut, or forced to leak through accident or disease.

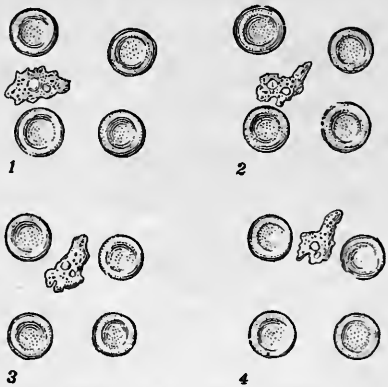
It has been estimated that the life period of a red corpuscle is about six weeks, that there are perhaps twenty-five millions of millions of them in the blood of the average man, that seven millions die with each tick of the clock, and that during the same clock tick seven other millions are created by the body to replace them. Do not try to memorize these figures. They are stated here just to give a notion of the vast numbers of the blood corpuscles.

2. *The liquid part, called plasma.* This is quite transparent and almost colorless. A little over one half of each quart of blood is plasma; the rest is the corpuscles.

3. *Colorless objects, called white corpuscles.* Of these there are usually from five to seven thousand in each cubic millimeter,[1] although the number

[1] Fifty cubic millimeters make a drop of water.

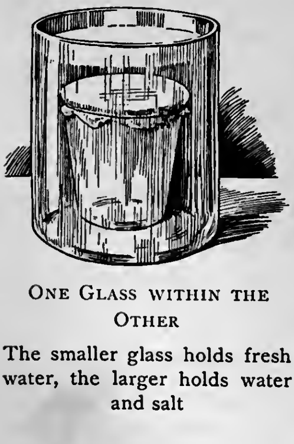
varies from time to time. White corpuscles are specks of living, jellylike substance which change their shape constantly. They not only travel with the other corpuscles in the plasma, but they also work their way through the walls of the capillaries and wander here and there in the body. They are soldiers and scavengers too, for, as the last chapter of this book shows, they not only destroy harmful microbes when they find them, but also help more than any other part of the blood in healing a wound.



RED AND WHITE CORPUSCLES

Four different shapes and four positions taken by the same white corpuscle

The Blood's Important Work. Plasma, red corpuscles, and white corpuscles are all that the microscope shows when we use it for the study of blood. But a chemist will take the same blood, analyze it in his laboratory, and prove that it is made up of many different substances of which we have not so much as heard the names — substances needed, however, for the work which each separate part of the body is doing. He will tell us that within the blood is all that is needed for the manufacture of bone, muscle, hair, tendons, tears, fat, and finger nails; that it is the source of supply for all that lies under the cover of the skin, the storehouse for more treasures than we have even dreamed about; and that it is easy to enrich or to impoverish the blood by our treatment of the body. It is, indeed, for the benefit of the blood that food and air do the important work which will be studied later.



ONE GLASS WITHIN THE OTHER

The smaller glass holds fresh water, the larger holds water and salt

But the question is, How can blood do so much when it stays all the time within the confines of the tubes? Nothing but an experiment can clearly answer this question, and we can make this for ourselves.

Exchanges along the Tubes. Get from the butcher a piece of fresh animal membrane—a bladder will do. Fill a small glass with fresh water, tie the membrane tightly over it, set the glass into a much larger one filled with salted water, letting the water cover it, and leave the two glasses together overnight. In the morning take out the smaller glass, unfasten the membrane, and taste the water which was fresh and sweet the night before. You will find that it is now distinctly salt. Taste the water in the larger glass. You will find that it has grown fresher.

In this exchange the salt in the liquid has acted according to a universal law. Salt is indeed one of the many substances which pass easily back and forth through any moist animal membrane. This process is called osmosis.

Put sugar into one glass of water and soda into another. Let a membrane be stretched between them, as was done in the fresh-and-salt-water experiment, and before long you will have two liquids that have become strangely alike. The different substances in the solutions have changed places through the membrane, according to the law of osmosis.

Gas Exchanges in the Blood. Even gases are subject to the same law. Men who know how to handle such things can put oxygen in one tube and carbon dioxide in another. They can then separate the gases by a piece of animal membrane stretched between the tubes, and they discover that the two gases refuse to stay apart. Indeed so much of each finds its way through the partition that soon there is a mixture of the two on either side of the membrane.

Experiments such as these answer the query as to how the body gets what it needs from the blood. Everywhere it is the animal membrane of the tubes themselves which separates the blood within the tubes from a certain other liquid which lies close about them on the outside.

Lymph and Oxidation. However small and however thin-walled the blood vessels may be, there is always this clear liquid, called lymph, bathing the outside of the capillaries like a sort of colorless sap in the body and making its exchanges with the contents of the liquid within the hairlike tubes. Moreover, this lymph, which soaks slowly but constantly through every tissue of the body, is laden with carbon dioxide, which it has received from the tissues themselves. The blood is rich in oxygen, and it is separated from the lymph only by the walls of the capillaries. In view of this, what could be more natural than the thing which comes to pass? The gases in the lymph and in the blood change places with each other as promptly as do the liquid materials which are also in the lymph and in the blood. And this exchange is part of the great process known as the oxidation of the blood.

It is evident, then, that lymph is as important to us as is blood itself. In fact, the two must always travel side by side. They are indispensable to each other. Without the one the other is useless. Three statements will show how close the relation is:

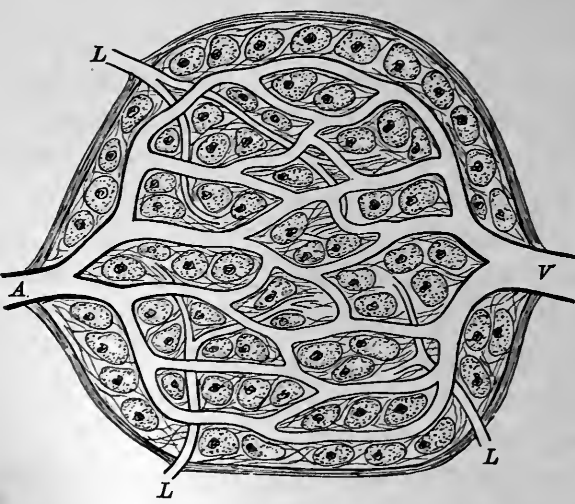
1. *Blood in the arteries* is the result of the food we eat and of the air we breathe. It contains every supply that any part of the body needs for nourishment, for strength, and for growth, and it is sent here and there by the action of the heart.

2. *Blood in the veins* is what is left after the lymph has taken from it the oxygen and other nourishment which the body needs, and given in exchange the carbon dioxide and other waste which must be carried off. In other words, venous blood contains much waste from the tissues and little nourishment for the tissues; while arterial blood is rich in nourishment for the tissues and contains little waste.

3. *Lymph* is made up of rich nourishing plasma derived from the blood, on its way to the tissues, and of waste material from the body, which will soon pass into the capillaries, be carried onward in the veins, and be disposed of as we shall learn hereafter. Lymph is also the highroad to the blood for many substances that are being manufactured by different organs of the body. These manufactured articles must find their way into the blood, for only through circulation will they ever be able to reach their destination.

The Lymphatic System. The origin of the lymphatic tubes is strangely interesting for the simple reason that it is so very indefinite. Each seems to begin about as irregularly as a stream that gathers water in a swamp.

As we know, blood vessels are a closed system of tubes with a stream of blood sweeping through them endlessly — going ever round and round, from the heart through the arteries, the capillaries, and the veins, back to the heart again. In this great system not even the smallest tube in the remotest region of the body is left with an open mouth. The lymphatic system, however, works on quite a different basis. Here the vast multitudes of



A Cluster of Tubes

Look for those with open mouths; *A*, artery; *V*, vein; *L*, *L*, *L*, lymphatics

the smallest tubes seem to be really little more than open mouths into which liquid is gradually making its way. Bear this in mind while the facts are given as definite statements:

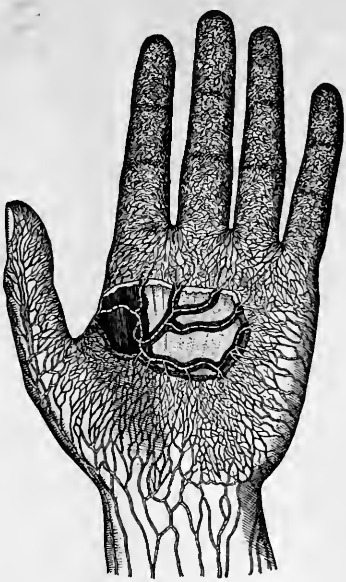
1. Each blood vessel of the body makes its way through a meshwork of tissues.

2. Everywhere among these intertwined tissues there is a colorless liquid called lymph. The capillaries of the blood are surrounded by this lymph, just as grass and weeds are surrounded by water in a swamp. Lymph looks like the plasma of the blood.

3. Lymph and plasma are constantly making exchanges through the walls of the blood vessels.

4. Plasma is getting from the lymph all that the body is through with —all that should go on in the blood and be disposed of elsewhere.

5. Lymph is getting from the plasma all the nourishment which the tissues need.



LYMPHATICS OF THE HAND

Smaller tubes lie near the surface, larger ones lie deeper

6. Opening away from the loose fibers through which the blood vessels run, and in which all this exchange is going on, there are other tubes about as small as the capillaries; and into the open mouths of these tubes the lymph from the tissues gradually makes its way.

7. Vigorous exercise hastens the flow of lymph no less than of blood, and the tissues are benefited thereby.

VEINS AND LYMPH TUBES

The lymph tubes are white and are seen to empty into the large veins

8. From start to finish the lymphatic tubes, like the veins, progress in size from smaller to larger. They are also provided with inside pockets quite like those of the veins. These pocket valves keep the lymph from moving backward and help to send it constantly onward, that it may at last mingle with the great stream of blood that goes to the heart.

9. This progress from smaller to larger tubes continues until all the lymph of the body finds its way into two large lymph tubes, one on each side of the neck. These empty into two large veins, and thenceforward lymph and blood go on their way together

to the heart. The lymph, with all it has gathered, has now entered the circulatory system, and thus the contributions from the many different organs of the body will be distributed by means of the blood. The movement of this fluid continues during life, for the lymph vessels and lymph spaces can never be empty as long as the organs of the body are at work.

A special point to remember is that blood vessels and tissues are as much better off when fresh lymph surrounds them as are fish when they are in fresh water.

The next chapter shows what happens when alcohol enters the streams of blood and lymph.

QUESTIONS

1. How would you get a drop of blood for examination? 2. What is the color of the blood? 3. How do you know that blood hardens soon after it leaves the body? 4. What becomes of it after it has been left standing about half an hour? 5. What is coagulation? 6. Of what value is coagulation in healing a wound? 7. What three things mixed together form blood? 8. Describe red corpuscles; white corpuscles. 9. What is the liquid part of blood called? 10. What can a chemist find out about blood?

11. Describe experiments which prove that certain substances can pass through a moist animal membrane. 12. What is this process called? 13. What exchange of liquids and gases in the body is explained by these experiments? 14. What is lymph like, and where is it found? 15. What gas passes from the tissues of the body into the lymph? 16. How does it reach the red corpuscles? 17. How does

oxygen from the red corpuscles get to the tissues? **18.** Which two gases change places in the red corpuscles?

19. Describe the blood in the arteries. **20.** Describe the blood in the veins. **21.** Describe the origin of the lymphatic tubes. **22.** What is the difference between the system of blood vessels and the system of lymphatic tubes? **23.** What does lymph look like? **24.** What does plasma receive from lymph? **25.** What does lymph receive from plasma? **26.** Of what use are the pocket valves in the lining of the lymph tubes? **27.** How does vigorous exercise help the body through the lymph? **28.** Why is it well for tissues to be surrounded by fresh lymph?

CHAPTER VII

ALCOHOL IN THE BLOOD STREAM

Slow Circulation of the Blood. Red eyelids and a pink nose tell plain facts about the state of the capillaries in those particular regions, but the mere fact that a man has a red nose signifies very little about his general health. Many a hearty sea captain has carried such a nose with him through half a century. He has lived to be eighty years old or older, and the shade of his sunburned nose has mattered little to him.

Sometimes, however, the color of a man's nose is a sign of general internal conditions. It may show that the capillaries throughout his body are loaded with slow-moving blood, and this condition of the capillaries throws a flood of light on the sort of work which the heart itself is doing.

Judging by facts which we have already learned, three points are clear:

1. Slow-moving blood is more impure than fast-moving blood. For this reason such blood is always a disadvantage to any part of the body in which it tarries.

2. The mere fact that blood is moving fast shows that impurities are being hastened out of the way and that fresh material is being supplied to lymph and tissue.

3. The blood vessels must always be in a healthy, vigorous, elastic condition if the best exchanges are to be made through their walls.

Alcohol and the Heart Beat. In view of these statements we are ready to understand a set of discoveries about circulation which have been made during the past few years. It appears that for many previous years educated doctors and ignorant men alike believed that alcohol was a genuine help to the vigor of the circulation. Thousands of men thought they had proved this by personal experience. At different times, and in different places, they had taken alcohol in large doses or in small doses, and after the drinking they had tested their hearts and found by counting the pulse that the number of heart beats had increased. They had felt the pleasurable effect of blood bounding faster through their veins, and it was most natural for them to believe that the alcohol which they had taken had strengthened the heart, just as food strengthens the body.

Testing the Heart Beat with the Sphygmograph. In time, however, came the sphygmograph, with its tests of vigorous and languid hearts. It is in wide use to-day, because doctors find that they can judge in a general way as to whether a man is well or not by the vigor or the languor with which his heart does its work.

Doctors and teachers alike were now astonished. They took alcohol themselves; they gave it to their friends and their patients; they studied the heart and found that its throbs had increased in number. But when, in this condition, they used the sphygmograph, they were surprised to see that the heart was not putting as much power into each stroke after the alcohol was taken as it had done before.

Alcohol and Heart Vigor. Over and over again the tests were made, with the same result. Each trial showed that although the heart was pumping faster than usual, it was nevertheless doing its work with less vigor. It was using less force for the increased number of strokes than it had used for the smaller number made before alcohol had been taken into the blood.

Testimony of this sort gave a new color to the practice of using alcohol when the heart needs to be strengthened. Doctors in every land had to yield to the evidence of their senses. They had to believe that, instead of giving strength, alcohol actually robs the heart of a part of the strength which it had before the alcohol was taken. This was a hard thing to believe, yet to-day the facts of the case are accepted by all up-to-date, intelligent people. And this is why our best doctors are giving so much less alcohol nowadays than in former times.

First Effects of Alcohol. Here are a few of the most important points about the effects of alcohol on the body:

1. Healthy tubes that carry blood are elastic. They stretch out when blood is pumped into them by the heart, and they contract firmly again as they send the blood onward.

2. The first effect of alcohol in the body is to paralyze in a very slight way every tube that has anything to do with carrying blood hither and thither. This means that alcohol is a narcotic and not a stimulant.[1]

3. Because the tubes are slightly paralyzed they are more relaxed than formerly. They contract less. They therefore offer less resistance to the blood that is pumped into them. After they are full they stay relaxed and do not have the elastic power to pull themselves firmly into shape again.

4. The heart is also slightly paralyzed by the alcohol. Still, those countless relaxed tubes offer so little resistance that the heart pumps the blood into them with less effort than formerly, and, as a result, contracts more frequently.

Thus far, however, no harm appears. The capillaries are full of blood; the man feels the warmer for it, and

[1] A narcotic is something that lowers the vitality of the body and may harm it. A stimulant is something that stirs even a tired organ or a tired body to activity. Certain stimulants are dangerous things to use.

his heart is beating a trifle faster than usual. That is all. But now begins the chapter of damages and calamities.

The Real Harm of Alcohol. During the time that the heart itself is weakened, it cannot put force enough into each stroke to drive the blood on in spite of the relaxed state of the walls of the tubes. Various results now follow. Blood moves more slowly through the tubes; it is slow in carrying away broken-down tissue from the lymph; it is slow in bringing fresh nourishment for the rebuilding of the tissues.

In the meantime, if alcohol continues to be taken, the capillaries may be kept stretched so long as to lose all power to contract. If this state continues, the walls themselves end by becoming thicker and stiffer. The work of exchange which should go on at a rapid pace through them is thus interfered with, and the health of the drinker suffers in numerous ways.

This is no fancy picture. It is simply the history of circulation in such persons as are ignorant enough to be willing to rob themselves of the service which their blood and their blood vessels should do for them.

Fat about the Heart. The gravest aspect of the affair, however, is in connection with what happens to the heart. Because this tireless pump is weaker than it was, it also becomes stretched; and as it cannot do full work, it lacks the exercise which would keep it in vigorous health. It grows flabby, as does an unused arm.

Fat gathers not only between the fibers but also within the body of each separate fiber. In this latter case, fat takes the place of tissue itself, and then occurs what is called fatty degeneration of the heart — a most serious condition. For a heart of this sort is too weak to send blood onward as rapidly as it should go. This

Two Hearts Side by Side

On the left the heart is normal; on the right it is enlarged and weakened by fat

(Copied from *Alcohol and the Human Body*, by Horsley and Sturge)

means that circulation throughout the entire body is hindered, and that each great organ suffers for lack of what it should get through fresh supplies of blood. Evidently, then, he who owns a fatty heart, weakened from any cause, is far less sure of continued life than he might have been. Since he secured this condition through ignorance, he is not to blame. But sad as is the fact, ignorance never saves men from the results of their ignorance.

Weakened Heart and Arteries. Why do surgeons dread to do anything for the man who uses alcohol? Because they know only too well that the power of his heart and the elasticity of his arteries have been so reduced that his heart may not rally after the operation. In writing of this danger, Sir Frederick Treves says:

> Having spent the greater part of my life in operating, I can assure you that there are some patients that I don't mind operating upon and some that I do; but the person of all others that I dread to see enter the operating theater is the drinker. He is the most dangerous feature in connection with the surgical life.

It is because of this constant state of relaxed capillaries that the nose of the drinker stays red. In his case the nose is frequently a reliable sign of internal conditions. Any man with weakened heart and arteries should have nothing to do with such running as is described in the next chapter. It may put his life in peril.

QUESTIONS

1. When the nose or any other part of the body is red, what do we understand about the capillaries just there? 2. What objection is there to having blood move slowly through the capillaries? 3. Mention two advantages that are connected with fast-moving blood. 4. Why should the walls of the blood vessels be kept healthy, vigorous, and elastic? 5. What did doctors formerly think about the connection between alcohol and circulation? 6. After a man takes alcohol does his

heart beat faster or slower? 7. What dces the sphygmograph show about the power of the heart before and after alcohol has been used? 8. Does this prove that the heart receives strength or is robbed of strength by the alcohol? 9. What is the natural condition of the blood tubes? 10. Are they elastic or nonelastic? 11. What effect does alcohol have on them? 12. Why is this harmful? 13. What is a narcotic? a stimulant? 14. What effect has alcohol on the heart? 15. Describe the result when both blood tubes and heart are thus weakened. 16. What finally happens to the walls of the tubes? 17. What effect does this have on the exchanges between plasma and lymph? 18. Why does the body suffer when the exchanges are made slowly? 19. Describe the condition of the heart after it has been weakened by alcohol. 20. What objection is there to fat among the fibers of the heart? 21. Why do surgeons dread to operate on a man who uses alcohol?

CHAPTER VIII

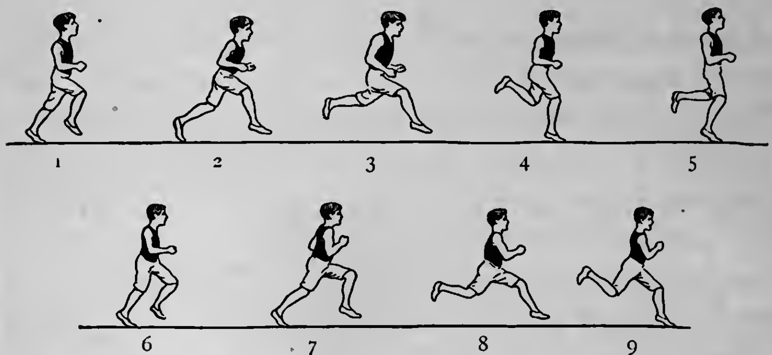
TRAINED AND UNTRAINED LUNGS

What is Breathlessness? If you were ever thoroughly out of breath, recall the sensations you had at the time. Perhaps you were trying to catch a train; perhaps you were running in a relay race. In either case you felt that you must reach the goal at all hazards, and you ran as you had never run before.

BREATHLESS AT THE END OF THE RACE

Your breath came and went freely, and during the first few moments you drew deep, long breaths of equal length. Soon, however, you found that each breath was shorter than the last. You began to be uncomfortable. There was a tight feeling within you, as if an iron band were closing itself about your chest; as if it prevented you from expanding your lungs to their full size. You wondered how much longer you could keep it up.

But why were you breathless? To answer the question, follow once more the condition of muscle and bone, tendon and heart, lungs and blood vessels, while



NINE VIEWS OF THE SAME MAN AS HE RAN

A different set of muscles is at work in each position, so that altogether many muscles are used in running

(After Schmidt)

you were running. Think for a moment of your inelastic tendons as they stayed firmly gripped to their bone attachments. Remember how each one of multitudes of muscles, large and small, shortened and lengthened as by means of their tendons they pulled those leg bones of yours up and down and kept them at work. Remember that neither arms, back, neck, nor any other part of your body was relaxed as you ran, but that every muscle seemed to work hard in keeping time and step with the movement of the legs. Remember that such violent action as this means that changes are going on in the substance of the living tissue which is exercised; that these changes involve the giving off of unusual quantities of carbon dioxide; that oxygen is needed by the working fibers; and that in order to supply the oxygen and to carry off the carbon dioxide and other waste products, fresh streams of blood must be hastened to the active muscles with ever-increasing speed. The most immediate, imperative need of each working fiber is to get rid of the excess of carbon dioxide.

The Cause of Breathlessness. There are three things which bring about such a condition of breathlessness:

1. Exercise violent enough to compel the fibers of the muscles to produce unusual quantities of carbon dioxide. As this gas is produced, oxygen is demanded by the fibers. It is, indeed, as if they themselves were breathing.

2. The activity of the chest walls as they expel the carbon dioxide from the air sacs of the lungs and replace it with air containing oxygen.

3. The rapid work of the heart as it receives larger amounts of impure blood than usual through the veins and sends arterial blood to the tissues to carry oxygen and to bring away carbon dioxide. To a large extent it is this forced work of the heart that explains the feeling of breathlessness.

We were speaking of this matter the other day, and my friend, who teaches physiology, said:

People used to say that a man was breathless because there was more carbon dioxide in his blood than he could expel through his lungs. But we know better now. We know that it is n't so much the carbon dioxide — although of course that has to be driven off — as it is the overtaxed heart that makes us breathless.

Boys come to me for examination, and I tell them that the heart gets tired from overwork, just as the biceps does, and that it is quite as possible to strengthen the heart by training as to strengthen the biceps. At first I put the boys on easy exercises that tax the heart but little; then day by day I give what is harder until, almost before they know it, those boys have developed hearts that are strong enough to do hard work without making them breathless. At the same time they have trained the heart and lungs to work together in ventilating the blood.

Speed and Breathlessness. The fact is that we grow breathless in proportion to the force which we put into any exercise in a given length of time; that is, the faster we do the same thing, the more quickly will breathlessness overtake us. It is easy, therefore, to understand an opposite condition, and to believe that the quieter we are the less oxygen the tissues will use and the less carbon dioxide the body will have to get rid of.

While we sleep we give off the least carbon dioxide. When we sit up the quantity is almost doubled. When we run the change is striking, for now, during every minute of exercise, the blood carries to the lungs over four times as much carbon dioxide as it carried while we were asleep. The proportion is not always the same.

Those who train for athletic sports take the facts about oxygen and carbon dioxide into account. They learn to manage their running and the work of heart and lungs in such a way that neither will be overtaxed until the end of the race is near. They are willing to be breathless at the very last because they are soon to stop running and catch their breath again. But to get breathless at the beginning of the race means defeat. And what may be said about training the machine that does our breathing for us? Make a series of tests for yourself.

MEASURED BY THE DOCTOR

Tests of Chest Capacity. Place one hand lightly on your chest; place the other on your back between the shoulder blades; inhale slowly until your lungs are full, then exhale slowly until they seem empty. While you do this, notice that the breastbone rises and that the front and rear walls of your chest are forced gradually farther apart.

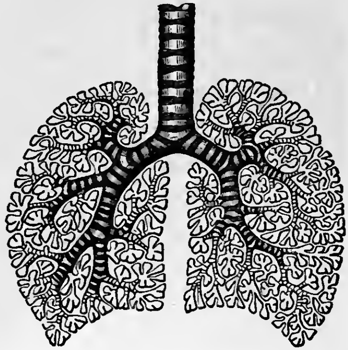
While you take another long breath and send it out again, stand with your hands resting lightly on each side of the body just over your lower ribs. Notice that it is expansion sidewise this time; you also see that the capacity of your chest has increased greatly. It is as if you had pumped air into an elastic bag.

Increasing the Chest Girth. Take a tape measure and get the girth of your chest after you have exhaled all you can, and again after you have inhaled all you can. Learn from these tests that the size of your chest can be increased and diminished at will, and that its size can be increased permanently by frequent exercise of this kind. To prove this, measure your chest to-day; then for two months take fifteen deep full breaths three times a day. With each breath expand your lungs as fully as you can without really straining them. At the end of the two months measure yourself again, and you will find that your chest measure has increased. From this you have the right to conclude that your lungs also are larger.

WITH HIS CHEST CONTRACTED

WITH HIS CHEST EXPANDED

Structure of the Lungs. We often talk of the lungs as if they were a pair of big bags tucked in under the ribs somewhere, waiting to swell out or sink in according as we use them. In a way the notion of the bag is correct, except that instead of two bags, one on each side, we must think of thousands upon thousands of microscopic bags, called air sacs. We must recall what we learned in *Health and Safety*, and think of these air sacs as the most important part of the branching tubes of the lungs. We must remember that within the large chamber which the ribs make we have two sets of these tubes ending in air sacs. Each set is called a lung. The heart lies between the right and left lungs and is a trifle more on the left side than on the right.


TUBES AND AIR SACS OF THE LUNGS

Work of the Lungs. For the sake of saving time and space a few facts, new and old, must be given under numbered headings. They show how the lungs help us throughout our lives.

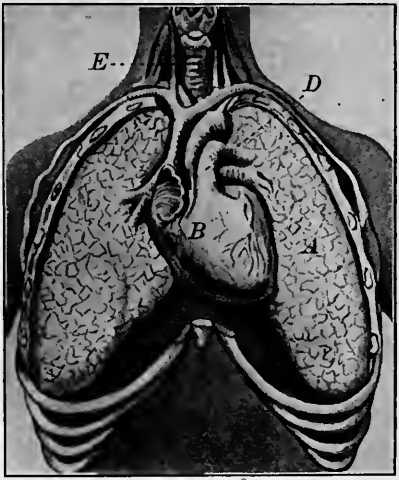
1. Blood that enters the lungs is so dark and so heavily laden with carbon dioxide — although there is also some oxygen in it — that we call it impure. Blood that leaves the lungs is so well loaded with oxygen that it has gained a bright scarlet color, and we call it pure, as indeed it is. Even in pure arterial blood, however, there is some carbon dioxide.

2. The lungs are at work not because they themselves need air, but because they serve as a clearing

house in which oxygen and carbon dioxide may change places. Such a central exchange is needed because, as we know, each smallest tissue over the entire body is in need of oxygen and must be relieved of its carbon dioxide. It is in the lungs that blood unloads itself of most of its useless carbon dioxide, loads itself up with oxygen, and streams off to some distant destination. Breathing, then, is mainly for the benefit of the tissues of the body, not for the sake of the lungs themselves.

3. All the blood of the body comes to the lungs and goes away again once every twenty-three seconds. While it passes through the lungs it does not leave the capillaries, but the capillaries themselves are so closely intertwined with the air sacs that the two cannot be separated, and since they lie so close together, rapid exchanges are taking place constantly. Oxygen mixed with the other gases of the air is on one side of the animal membrane of the air sac; carbon dioxide, with a little oxygen, is in the blood on the other side of the membrane, within the capillaries. And as the gases are side by side, two of them — the oxygen and the carbon dioxide — change places without delay. Oxygen enters the blood from the air sac; carbon dioxide enters the air sac from the blood; the red-corpuscle carriers are loaded with oxygen in the twinkling of an eye and

hasten off to unload their cargo where it is needed. In the meantime, however, the large supply of carbon dioxide is as unwelcome in the air sac as it is everywhere else in the body. It is therefore expelled quickly by an outgoing breath. In this way the body relieves itself of carbon dioxide by every breath we exhale.



HEART AND LUNGS IN CLOSE CONNECTION

A, left lung; *B*, heart; *D*, tube through which blood goes to the lungs to be purified; *E*, windpipe through which air goes to the lungs with oxygen for the air sacs

In view of these three important facts it is quite evident that large healthy lungs will be invaluable to any one who wishes to take vigorous exercise, and that, on the other hand, exercise itself is the very best thing for lung development.

Inactive Air Sacs. The entire group of sacs should often be compelled to expand more fully than they naturally do in the course of regular daily breathing, and the best way to expand them is not by standing still and taking deep breaths, but by using large muscles vigorously, thus compelling the lungs to work hard too.

Many a sagging chest hides from sight multitudes of inactive air sacs that have never been expanded through hard exercise. Nevertheless, each separate one would have worked well and would have increased in size if its owner had compelled it to gain capacity and power through such hard breathing as comes from fast walking, from running, jumping, and swimming, or from lively games played out of doors.

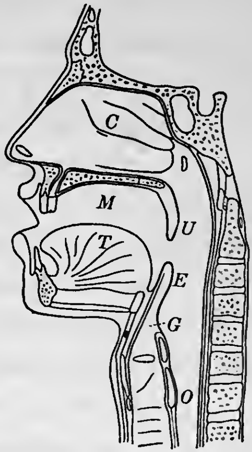
GROUPS OF AIR SACS

Only by the full breath, which is broad as well as deep, does much air get into the upper corners of the lungs, and these air sacs, left inactive, yield quickest to disease microbes. Here it is that tuberculosis most often begins its work.

Health and Exercise. Fortunately we get exercise whether we use our muscles in work or play, and the more we enjoy it the better off we are. Work in garden and hayfield, mowing the lawn, and hoeing — all are good, provided the body is not overtaxed. If a young, frail boy gets too tired, his stomach and other organs will not serve him well. Almost every kind of play is valuable, unless it overstrains the heart as hard rowing-races and basket-ball contests may do. The feeling of utter exhaustion, of being exceedingly out of breath, is harmful. It must be avoided. The very best exercise is that which one gets in moderate walking, running, jumping, swimming, riding horseback, and playing out-of-door games. By taking the right sort of exercise we sleep well, have a good appetite and a clear brain. The following rules will help:

1. Exercise vigorously every day. We cannot exercise enough in one day to last a week, any more than we can eat enough in one day to last a week. Violent exercise should not come either just before or just after eating.

2. Make sure to give exercise not only to arms and legs, but especially to the big muscles of the chest, back, and abdomen.



AIR PASSAGES

C, nasal cavities; *M*, mouth cavity; *T*, tongue; *E*, epiglottis; *G*, glottis, or opening from the pharynx into the trachea; *U*, the end of the soft palate; *O*, œsophagus

The Breathing Apparatus. In studying our breathing apparatus, recall what you learned about the nose in *Health and Safety*, and bear in mind the following facts. Air enters the lungs through tubes that begin with the nose and end in air sacs. From first to last these tubes are continuous and unbroken, but each part has its own name. Here they are; each one is most important — pharynx, larynx, trachea, bronchial tubes, bronchioles, air sacs. Now take them up for separate study.

1. *Pharynx.* Both food and air use this entrance to the body through the mouth. Open your mouth wide before the mirror. See the soft palate hanging downward. This is the curtain which separates the mouth itself from the pharynx. Now look just beyond and below the palate. See two rounded objects, one on each side of the pharynx. These are the tonsils. When in good order they hold and destroy germs that enter the body with food and air. When out of order they grow large and inflamed, being diseased by the very germs they have captured. When this happens they do the body more harm than good, and the doctor must cure them or remove them. Nowadays tonsils and adenoids are receiving close attention from the doctors, because it is known that they are often twin hindrances to the breathing apparatus. An adenoid is simply a growth of tissue far back in the nose. And just because this growth is there, it prevents air from going freely to the lungs and compels a person to be what is known as a mouth breather. Whenever we see a mouth-breathing child who is dull and forlorn, unable to learn his lessons, and discouraged, we look for adenoids and diseased tonsils. Usually both are found, although the following case of a twelve-year-old boy in Cleveland, Ohio, speaks of adenoids alone.

May 1, 1907. Hearing very defective; hears watch at six inches. Sleeps badly, snores, appetite poor, frequent colds, restless, inattentive, stupid, eyesight defective, frequent headaches, adenoids.

May 3, 1907. Adenoids removed. Eyeglasses secured two weeks later.

June 10, 1907. Hears watch at four feet, breathes freely through nose, sleeps soundly, never snores, appetite good, headaches have ceased. Has been transformed into a calm, bright, attentive, and well-behaved pupil.

Thousands of other boys and girls have had the same happy experience; so many, indeed, that nowadays it is quite the expected thing for a doctor to examine any ailing child for adenoids and swollen tonsils and to remove them if found. It is a simple operation and quickly over.

In the pharynx, with the tonsils, is a device which saves us from choking when we eat. This is the glottis. It is an opening from the pharynx into the windpipe. The cover to this opening is called the epiglottis. Whenever we swallow, this traplike cover shuts itself down over the glottis and prevents food from getting into the windpipe where air alone should go. Because the epiglottis is down, food slides unhindered through the food tube to the stomach. When a person chokes, it is because the epiglottis has been slightly raised and bits of food have slipped into the windpipe. Joined to the pharynx is the next-named part, the larynx.

2. *The larynx*, or voice box. This is a cavity inclosed by walls of cartilage,[1] and it lies directly behind the Adam's apple. Within this cavity are stretched bands of tissue called vocal cords. By using these cords we produce sounds, have a voice, and are enabled to speak and sing. We may also train and control the vocal cords and to a large extent may have sweet voices or harsh voices as we wish. Inflamed vocal cords will produce hoarseness. To get pleasant sounds from your vocal cords, place the voice in the front of the mouth. You can do it as follows: First whisper the sentence, "I will speak with my lips and the tip of my tongue." In a whisper we always use the front of the mouth. Now vocalize this whisper, that is, give to the whisper, sound. You will find that you have kept your voice in the front of your mouth. It is easy to injure the vocal organs by placing the voice too deep in the throat. Many a public speaker does this. While the voice is changing, one may yell so furiously at a ball game as to strain the vocal cords beyond repair. The power to utter sweet sounds is then gone forever. Singers are always careful to guard their vocal cords from severe strain of any sort and from colds which inflame the membranes. Even we who are not singers should be careful too.

[1] Something like stiff gristle.

3. *The trachea* is the windpipe. It extends from the larynx to the lungs, where it divides into two branches. These branches are the bronchial tubes.

4. *The bronchial tubes.* When we take cold and the lining of these tubes becomes inflamed, we have bronchitis. Each of the bronchial tubes divides and subdivides into ever smaller branches and twigs, until they end in what are known as the bronchioles.

5. *The bronchioles.* These bronchioles themselves end in the smallest of pouches, in which are our often-mentioned air sacs.

6. *Air sacs* are tiny pits on the sides of the pouches. Each separate sac is surrounded by the finest possible network of capillaries, and the lining of the sacs is so thin that it would take twenty-five hundred layers of it to make one inch in thickness. It is within these sacs that the blood in the capillaries turns from dark red to bright red, from impure venous blood to purified arterial blood. The outside covering of the lungs is called the pleura. When it is inflamed we have pleurisy.

Clean Air for the Lungs. From nose to lungs the entire lining of the breathing apparatus is a damp mucous membrane. It catches and holds microbes and bits of dust that may be in the air we breathe. Moreover, as described in *Health and Safety*, thousands upon thousands of threadlike cilia are on the lining of the nose and of the largest tubes of the lungs. Whether we are awake or asleep, they move ceaselessly like velvet paddles, always sweeping mucus upward towards the mouth, and in this mucus are the captured microbes and bits of dust which must be kept from the air sacs and thrown out of the body. Thus we see that all the breathing we do, and the entire breathing apparatus, is for the immediate purpose of supplying the lungs with air — clean air if possible. This air holds oxygen for the tissues and exchanges it for carbon dioxide from the tissues. Without the exchange we should promptly die, and the more complete the exchange the better we live. For this reason, then, we make the most of our breathing apparatus. We stand straight, walk with chest expanded, take deep breaths of pure air through the nose with the mouth closed, and give strict attention to the increase of our lung capacity. It is for each one of us to decide whether the air we breathe shall be as pure by night as by day, and whether it is always as pure as it should be.

Value of Moist Air. In addition to all else, we should take particular pains to supply our homes with fresh air that is moist. (Review the directions for ventilation given in *Health and Safety*.) When furnaces, stoves, or steam-pipes warm us in winter, indoor air gets so dry that the delicate tissues of the nose and lungs suffer. Several devices help. For a hot-air furnace keep the water in the pan of the furnace always full. Evaporation of this water will moisten the air and reach the entire house. For steam-heated houses, pans are made to be attached to the radiators. These should be kept filled with water. It evaporates and moistens the air. Try any device that will send moisture into the overdry winter air of our homes. As a rule, out-of-door air is moist enough and desirable in every way. For this reason, get all of it you can. Be out of doors much by day, and sleep on a sleeping porch or with windows open at night.

Getting an All-round Development. With the facts about his breathing apparatus before him, let the flat-chested person set about his own improvement. Let him know that the best-developed leg muscles are of little use for running unless heart and lungs are able to do their share of the work, for, as some one has said, "We run as much with our lungs as with our legs." We next study foods, the source of all our energy.

QUESTIONS

1. If you were ever thoroughly out of breath, describe the sensations you had. 2. In a hard run, what happens to the tissues of the body? 3. What gas is produced by tissues as they work? 4. What gas do they greatly need? 5. Through what stream do the tissues get rid of their carbon dioxide and receive their oxygen? 6. Why does the blood stream need to flow fast? 7. What three things combine to bring about breathlessness? 8. What can be done to strengthen the heart? 9. When does carbon dioxide form fastest? 10. When do we use the most oxygen? 11. When does a man give off the least

carbon dioxide and call for the least oxygen? 12. Why is the heart overtaxed when we run hard? 13. What does a trained athlete learn about managing the work of the heart and the lungs? 14. During exercise, which muscles give a hurry call for oxygen? 15. Which two organs of the body need to be trained in their relation to each other?

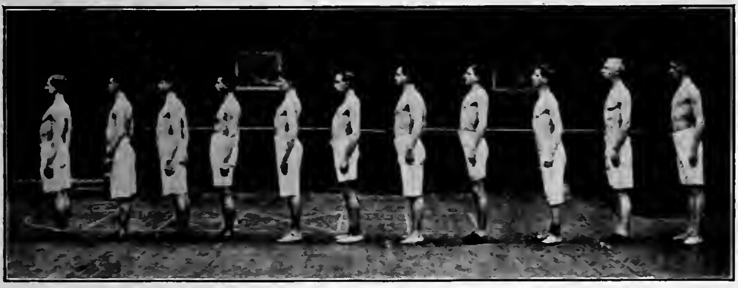
16. Mention tests which show that lung size can be increased. 17. How many lungs have we? 18. Where are they? 19. What is an air sac? 20. When is blood called impure? 21. When is blood pure? 22. What is the condition of the blood when it enters the lungs? when it leaves the lungs? 23. In what way are the lungs a storehouse? 24. What exchange goes on in the air sacs? 25. Where do the red corpuscles carry the oxygen? 26. Do we breathe for the benefit of the lungs or of the tissues? 27. How long does it take blood to make the circuit of the body? 28. Describe the way in which oxygen and carbon dioxide change places in the lungs. 29. Why are large lungs an advantage to the body? 30. How may their size be increased? 31. What are the best kinds of exercise for the lungs? 32. What danger comes from inactive air sacs? 33. Where does tuberculosis most often begin? 34. Why should breathing be done through the nose and not through the mouth? 35. Why should air be well cleaned before it enters the air sacs?

36. Mention the names of different parts of our breathing apparatus. 37. What can be seen in the pharynx? 38. Of what use are the tonsils? 39. When diseased what should be done to them? 40. What are adenoids? 41. How do they hinder breathing? 42. Describe the condition of the Cleveland schoolboy before and after his adenoids were removed. 43. Describe the glottis and the epiglottis. 44. Where is the larynx? 45. What cords are in it? 46. What can be done in training the vocal cords? 47. Give another name for the windpipe. 48. What happens when the bronchial tubes are inflamed? 49. What is the special work of the air sacs? 50. What kind of substance lines the entire breathing apparatus? 51. Of what use is it? 52. Where and what are the cilia? 53. What is pleurisy?

CHAPTER IX

EATING AND OUR FOOD SUPPLY

Experiments in Eating. In 1903 Professor Chittenden of Yale University conducted some scientific experiments on a rather large scale. He began with himself, enlisted the help of others, and finally had in hand



SOLDIERS WHO SERVED ON THE EATING EXPERIMENT

thirteen soldiers whose ages ranged from twenty-two years and six months to forty-three years.

Close attention was given to the men in several ways. At quarter of seven each morning they were weighed. This was necessary, for they were eating about half as much meat as usual, with somewhat less of other kinds of food, and it was important to know each day whether they were gaining or losing by the new diet.

At seven came breakfast. Here each separate kind of food was weighed before it was given to the man who was to eat it. What he did not eat was also weighed, that Dr. Chittenden might know just how much had been used. Moreover, these men were allowed to eat

TEN OF THE SOLDIERS TAKING EXERCISE IN THE GYMNASIUM

only such food as was served to them. All eating between meals was strictly forbidden.

Aside from this close care about their food, the men were not hampered in many ways. They went to the theater sometimes, worked in the Yale gymnasium an hour a day, had regular drill under their officers, and went to bed at ten o'clock.

When they left New Haven six months later, Dr. Anderson, director of the gymnasium, wrote as follows:

The men were not above the average standard physically when they began their work, this standard being set by applicants for positions as firemen and policemen, not by college students. At the end of the training they were much above the same standard, while the strength tests were far greater than the averages made by college men.

These tests did not settle all food questions, but they seemed to make it clear that even soldiers may gain strength on much less meat than they have been in the habit of eating. As for the rest of us, science has proved that the welfare of the body is closely related to the food we give it, that the kind of food makes a difference in the quality of the work, that he who works little harms himself when he eats much, and that growing children need much more food than their inactive elders.

What Food does for the Body. All scientists agree that food does two things for the body:

1. Food builds tissue; that is, it makes the body grow by adding fresh tissue for the building of muscle, bone, blood, brain, etc., and it makes the body new by replacing all tissues as fast as they wear out.

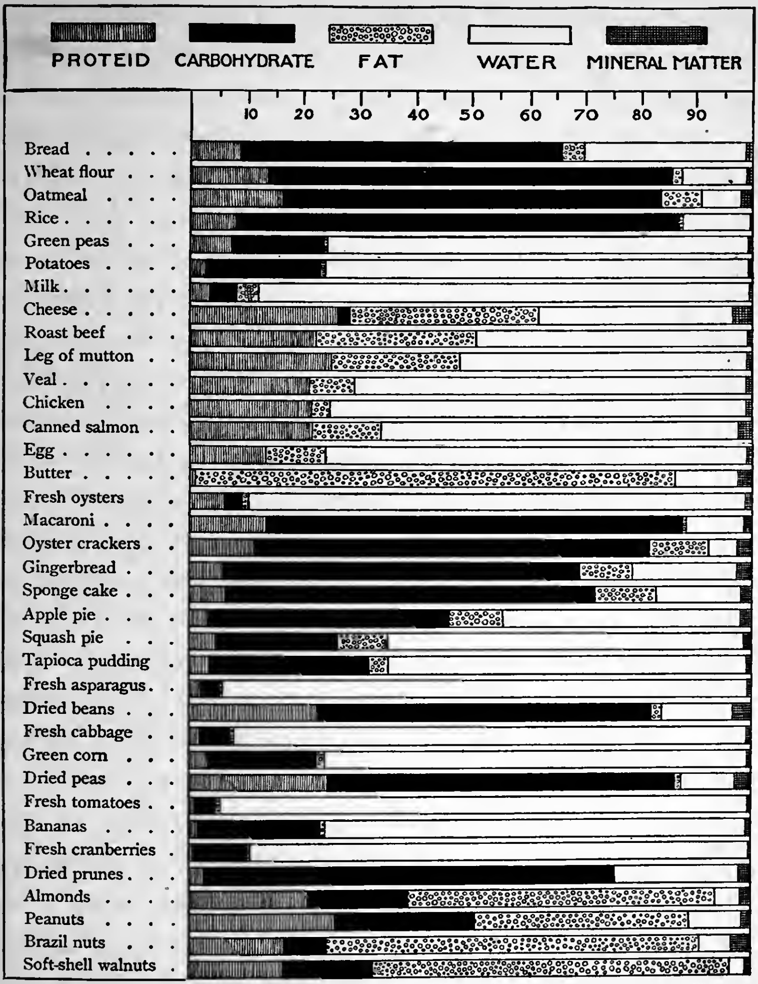
2. Food produces energy by which the body does the work of muscle, bone, brain, and beating heart, while at the same time it keeps itself warm. Food so used is the fuel for our engines. No engine runs well when fuel is lacking.

We eat, then, for the purpose of meeting one or the other of these two great demands of the body, and our success or failure in life may easily turn on what we know or do not know about the value of our food.

The Five Food Substances. When Professor Chittenden planned meals for his soldiers, his main thought was not as to whether he should give them beefsteak, mutton chops, fish, eggs, bread, or vegetables, but whether or not he was giving them the right proportions of certain substances which living bodies need if they are to do good work. These substances are known as proteids, carbohydrates, fats, water, and mineral matter. They are the general materials out of which our bodies are built, and they are so closely united with each other in blood and tissue that only the chemist can separate them. The next page gives a table made up from reports prepared by the United States Department of Agriculture. It shows how materials which the body must have are distributed in some of the foods we eat. In this table the single word "carbohydrate" is used instead of the two words "sugar" and "starch."[1]

[1] Notice that some of the substances in the table are moist, while others are dry; and remember that before many of the dry foods are eaten, a great deal of water is added to them. This is notably true of the cereals, of rice, and of flour. For example, what we buy as one pound of rice at the grocer's comes to the table as nearly four pounds of moist food. The chief difference between dry and moist foods is simply that when we eat dry foods we take less of the food and more water. Vegetables, fruit, meat, milk, eggs, puddings, and pies are moist foods. See the quantity of water in them which the table shows.

FOOD SUBSTANCES AS FOUND IN DIFFERENT ARTICLES OF DIET[1]



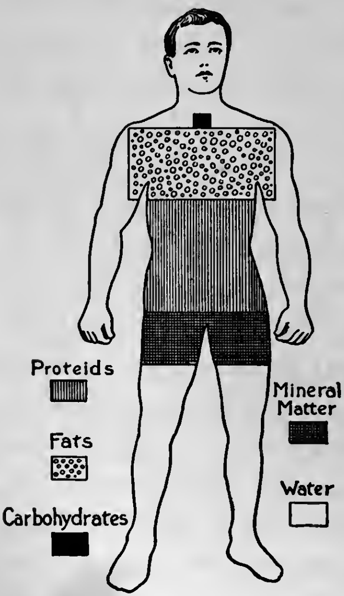
[1] These tables are made up from facts supplied by Bulletin 28 (revised edition) of the United States Department of Agriculture.

Studying the Cost of Foods. Study the food chart and decide which articles cost most. Into the expensive group will go all the meats. Dried vegetables and macaroni will be in the other group. Notice the amount of proteid and of carbohydrate in the different foods. For example, compare dried beans and roast beef. Take macaroni, add cheese to it, and we have an admirable, inexpensive food. It contains all the proteid we need, with abundance of carbohydrate and fat. In dried beans and dried peas we also have all the proteid we need, and carbohydrate too. So far as the food supply of the body is concerned, these inexpensive foods do just as much for us as expensive meats. Besides, they have the advantage of being free from damaging microbes — which is more than can be said of meats. Indeed, meat harbors so many microbes that decay easily sets in both before and after it is eaten.

Perhaps we wonder why Professor Chittenden took such care about his food substances, and why we ourselves should give so much time to the study of the same subject. The facts answer these questions.

Plants as Food Producers. Our entire food supply comes from living and growing things, that is, from plants and animals. Plants gather food for themselves from earth, air, and water. Each plant is therefore a producer, a food factory, while at the same time it is a storehouse of energy. Each takes carbon dioxide from the air, water from the earth, sunlight from the skies, and by its marvelous power it combines these things that are not foods into the foodstuff starch. We find starch in fruits, vegetables, and grains. It is more abundant on the earth than any other food, and we speak of it as if it were a simple substance. Instead, the entire starch supply of the world is composed of unnumbered small granules,—easily seen under the microscope,—and each separate granule is wrapped within its own tiny cellulose envelope. To a large extent all plants are made up of starch and cellulose. When starch substances are cooked, the cellulose envelope breaks up. This lets the starch out, and it becomes digestible food. It is, indeed, for the sake of breaking up the envelope that we cook our vegetables and our grains so carefully. Starch is a carbohydrate, so also is sugar, which is very much like starch in its chemical make-up. We find starch in green fruit. This turns to sugar as the fruit ripens, and the fruit is then sweet. Some vegetables also contain sugar as well as starch.

Carbohydrate for Energy. The carbohydrates starch and sugar are the substances which—with fat—give the body most of its energy. They do no building of bone, brain, or muscle, but act as fuel for the furnace of the body, giving power to muscles, bones, heart, brain, and every other organ. If we eat more carbohydrate than we need at the time, the body stores part of it up as fat and sends the rest of it from the lungs as carbon dioxide, or from the skin and kidneys as water. No part of this waste is left in the blood. Carbohydrate stored up as fat is often as useful to the body in time of need as money in the bank is to a man who lacks cash and needs to make a purchase.



THIS SHOWS WHAT PROPORTION OF THE HUMAN BODY IS COMPOSED OF EACH SUBSTANCE WHICH WE TAKE AS FOOD

Little carbohydrate appears, because most of the sugar and starch which we eat is used up in the shape of heat and muscular work and sent from the body as carbon dioxide. When we eat more carbohydrate than we need, the surplus is stored up as fat. The diagram shows that the body keeps a good deal of this on hand ready for use

The Proteids. An animal is not a genuine food producer; that is, it does not manufacture food from water, earth, sunlight, and air as plants do. It is primarily a consumer of food. So true is this that if animals were compelled to use each other as food, leaving plant foods untouched, the animal life of the world would soon vanish altogether.

Animal proteid is found abundantly in all animal foods — in milk, cheese, lean meat, chickens, fish, and eggs. Plant proteid is for the most part found in peas, beans, lentils, and nuts. Grains also contain proteid, and there is a little of it in most vegetables. Study the table for interesting items about the proportions found in different foods.

Proteid for Tissue Building. Proteid — whether from plant or from animal — is the substance which the body uses for building up its tissues. When a child is growing, proteid supplies him with material for longer bones, larger muscles, bigger brain, etc. When a muscle is worn down through exercise, proteid is used to build it up again.[1]

If we eat more proteid than we need, the left-over part will not be stored up by the body as is the case with left-over carbohydrate. Instead, it has to be worked over by the liver and sent out of the body through the kidneys. By constantly eating too much proteid, some people give the liver and kidneys more work than they can do. This is made plain in Chapter XI. We there learn that proteid waste in the blood stream is even more harmful to the body than clinkers are to the furnace.

The Fats. Animal fat comes in the shape of butter, lard, and suet. Vegetable fat comes as oil from nuts, from fruit like the olive, and from cotton seed.

The Minerals. The body gets part of its needed mineral matter from table salt, celery, lettuce, and spinach, all of which are valuable to us. When too much salt is used it is harmful.

[1] Since there is nitrogen in proteid, it is sometimes called nitrogenous food.

Need of Drinking Water. Drink at mealtime if you wish, but *never wash down a mouthful of half-chewed food.* Avoid ice-cold water, because it chills the stomach and delays digestion. If digestion is delayed, fermentation is apt to set in, and this means indigestion. Drink six glasses (that is, three pints) of water every twenty-four hours. The body needs this for several reasons.

1. It flushes the system, dilutes harmful substances, and helps keep the liver and the kidneys in good condition.

2. Over half the substance of our bodies is nothing but water, and every day the body sends off about three pints of it through the sweat glands and the kidneys. If this amount is not replaced, we are not so well off.

Rules for Right Eating. In view of all these facts, eating begins to look like a pretty solemn matter, and we ask ourselves if we must be always thinking about carbohydrates, proteids, and fats and of the quantity of each which we are eating. Certainly not. The one sensible way is to remember what the food substances are and to eat meat but once a day. Even for growing children this is quite often enough; for ailing old folks, whose bodies do little tissue building, it is often too much. Be on the safe side, therefore, and be sparing of meat. Eat vegetables and fruit liberally, however. But in doing this bear in mind the laws of proper eating[1] — *thoroughness of mastication, regularity of meal-time, no eating between meals,* save of such fruit as oranges, and *no "stuffing" even at mealtime.* Eat until fully satisfied of such nourishing foods as have been prepared, then stop. To be hungry means that the cells of the body are calling for food-fuel. To feel this hunger is a good sign, and it should be satisfied.

Many people abuse their digestive apparatus until at last it rebels. For the help of such sufferers careful charts have been prepared. These show how much food of different kinds should be used each day. Thus, by carefully weighing and measuring the amounts of proteid, carbohydrate, and fat that they eat, afflicted people are sometimes able to get relief. Better far not to reach the point where such care is needed. The truth is that the entire digestive apparatus does its best work when there is no anxiety about the food that is being eaten. The best plan, therefore, is to remember the great general laws about proteids, carbohydrates, and fats, to eat some of each every day, to obey all the laws of careful eating, and to give no further worrying thought to the matter.

Balanced Menus. When Professor Chittenden selected beans, cheese, or eggs for his men, he gave them little, if any, meat. As best she can, every housekeeper should do for her family what Professor Chittenden did

[1] As given in *Health and Safety.*

for his soldiers. She should supply well-balanced meals. This means that she should make wise combinations of foods containing proteid, carbohydrate, and fat. She should not serve at the same meal too many kinds of food that contain the same substance. Compare the two columns of menus given. Decide why the left-hand ones are desirable, the right-hand ones undesirable. Study the food table and make up menus of your own. Put into each one some proteid, some fat and mineral matter, and much carbohydrate. Those who study food facts believe we should eat fully five times as much carbohydrate as proteid.

Food for Bulk. In this connection it should be stated that food is needed not for nourishment alone but for bulk as well. Were it not for this, we might be content to have our food condensed into small pellets and swallowed quickly with a mouthful of water. But the stomach and the long food tube need to exercise themselves on food that has bulk to it. Vegetables and fruit are especially useful for this purpose because of their bits of cellulose tissue, which make bulk and pass along through the body without being digested. Graham flour and grain with the hull on are valuable for the same reason.

Vegetarians. Multitudes of people know that they can get all the proteid they need in other foods than meat. When they eat no meat they are called vegetarians. The

Healthful	The Reason Why	Unhealthful
Breakfast 1 Baked apples Cereal and cream Toasted whole-wheat bread *Breakfast 2* Oranges, prunes, or other fruit Boiled hominy Graham gems	*Breakfast.* This meal should be light and easily digested. The hardest work of the day comes in the forenoon, and it is a mistake to work hard after a hearty meal. In the *healthful* breakfasts few articles are provided. In the *unhealthful* breakfasts there is too much. Then, too, fried things always digest slowly. Coffee is objectionable. If you wish something hot, use a cereal drink.	*Breakfast 1* Cereal, cream and sugar Fried eggs and bacon Waffles and sirup Coffee *Breakfast 2* Sausage, fried potatoes Griddlecakes Hot rolls Coffee
Luncheon 1 Scalloped corn Cottage-cheese salad Graham bread Pineapple sauce Wafers *Luncheon 2* Macaroni and cheese Baked tomatoes Lettuce, French dressing Fig tapioca, whipped cream	*Luncheon.* In the *healthful* luncheons we have cheese instead of meat for the proteid. Corn and macaroni supply carbohydrate. Lettuce leaves give bulk; so also does the coarse part of graham bread. In the *unhealthful* luncheons there is too little carbohydrate. As a result, too much proteid will be eaten. Pickles are indigestible. It takes four hours to digest ham. Doughnuts are objectionable because they are fried in deep fat. That which digests slowly is apt to ferment in the stomach and produce gas. Tea contains tannin and the poison theine.	*Luncheon 1* Fish chowder Cold meat String beans Baked apples Tea *Luncheon 2* Minced ham on toast Pickles Doughnuts Coffee
Dinner 1 Tomato soup Fish or Leg of lamb Baked potatoes Creamed carrots Fruit gelatin *Dinner 2* Vegetable soup Roast chicken Browned potatoes Cauliflower Cranberry jelly Fruit salad Prune whip	*Dinner.* Look at the *unhealthful* dinners. Notice that they have proteid in oysters, in soup, roast, vegetables, salad, mince pie, and cheese. Coffee and pickles are bad. There is far too much proteid and far too little carbohydrate in these unhealthful dinner menus. The *healthful* dinners have soup with no proteid; potatoes baked, which is the best way; almost no proteid in the vegetables; no proteid in the salad, very little of it in the desserts. These dinners are well balanced. When there are several courses to a meal, and especially when meat is provided, make sure to have light soups, salads and desserts, and serve vegetables that are not rich in proteids. Raw oysters should not be eaten unless we know where they come from. They often live in water spoiled by sewage and by typhoid microbes. Many people have taken typhoid from contaminated oysters.	*Dinner 1* Bean soup Leg of lamb Mashed potatoes Peas Spiced pickles Suet pudding Coffee *Dinner 2* Raw oysters Split-pea soup Roast beef Mashed potatoes Lima beans Fruit-and-nut salad Mince pie Cheese Coffee

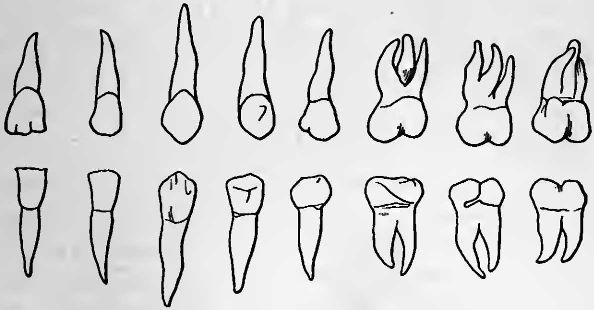
millions of people in India, China, and Japan live mostly on rice, with its seventy-nine per cent of carbohydrate.

These Teeth should have been Straightened

The Teeth. Whatever we eat, teeth do the chewing and must be kept in order. These bits of bone in the mouth are covered with enamel — hard, white, brittle, and easily cracked. Breaking nuts, opening a knife, or seizing nails and other hard substances with the teeth may crack the enamel, and once damaged it will never mend itself. Instead, microbes will find their way through it. After this they will work their way to the central pulp of the tooth, with its small blood vessels and nerves. And when microbes reach tooth nerves we have the toothache — jumping toothache, generally. Microbes are in fact the worst enemies teeth have. They live and multiply on bits of food between the teeth and on the gums. As they work their way through the enamel, we say the tooth is decaying, as indeed it is. To get rid of microbes and prevent decay, keep the teeth clean; wash them with water, soap, and toothbrush,

These Teeth were Straightened

after breakfast and every night before going to bed. Once a day pull soft silk floss between the separate teeth. This will draw out food fragments which the brush does not reach. Use tooth powder or paste two or three times a week. This is often enough. Besides keeping the teeth clean, go to a dentist twice a year. He will keep them in good repair. Nor is this all. Remember what *Health and Safety* says about "squirrel



ONE HALF OF THE PERMANENT SET OF TEETH

mouth"—how it happens and how to prevent it. To do proper chewing, the upper and the lower teeth should be opposite each other. A dentist can compel crooked teeth to grow straight, and the matter should be attended to while the jaw is still young. Even five-year-old children may help themselves by doing some downright, energetic food-chewing every day. If cereal is used, serve dry toast with it. Use soft cereals less, use crispy toast more. The chewing required for the toast will give exercise to jaws and gums, will draw blood to the chewing apparatus, and will thus give health and vigor to the teeth themselves. Such chewing will do more than anything else to save children both from "squirrel mouth" and from adenoids.

Since we know that our whole supply of food gets into use through what the body does to it after it has been broken up by the teeth and swallowed, we are now ready to understand Dr. W. B. Cannon's experiments with cats under the X ray, described in the next chapter.

QUESTIONS

1. Give an account of Professor Chittenden's food experiments with soldiers. 2. Did these men eat more or less than other men? 3. What was the result? 4. What did the tests prove about man's need of meat? 5. What persons should eat least meat? 6. Mention two things that food does for the body. 7. What are the five food substances? 8. Whence do plants get their nourishment? 9. Whence do animals get theirs? 10. What do the carbohydrates include? 11. Study the food table and tell which foods are richest in proteids; in carbohydrates; in fats. 12. What is said about dry and moist foods? 13. What substance surrounds each separate starch granule and must be broken up by cooking? 14. Which food substance gives us energy? 15. If we eat more carbohydrate than we need, what does the body do with the surplus?

16. What is animal proteid? plant proteid? 17. What does the body make of proteid food? 18. If we eat more proteid than we need, what becomes of the surplus? 19. Where does the fat in our food come from?

20. What are the general laws of proper eating? 21. Why do we feel hungry? 22. When Professor Chittenden selected beans, cheese, or eggs for his men, why did he give them little meat? 23. Why are

creamed potatoes more nourishing than plain boiled potatoes? **24.** Why is macaroni and cheese so nourishing? **25.** How much water should we drink? Why? **26.** What do we mean by a "balanced menu"? **27.** Give the menu for a healthful breakfast; luncheon; dinner. **28.** Why is bulk of food needed? **29.** What gives bulk? **30.** Describe the teeth and tell why they should be kept clean. **31.** How is this done? **32.** What is the cause of toothache? **33.** Why should crooked teeth be straightened?

CHAPTER X

FROM FOOD TO BLOOD, OR THE PROCESS OF DIGESTION

Food Experiments with Cats. These experiments were carried on in the laboratory of the Harvard Medical School, and the record of the work was published in 1898. Cats were chosen because they are easy to get hold of, ready to eat when they are fed, ready to sleep at almost any time, and easily controlled. Even among cats, however, Dr. Cannon had to choose carefully, for only those who were good-natured were useful.

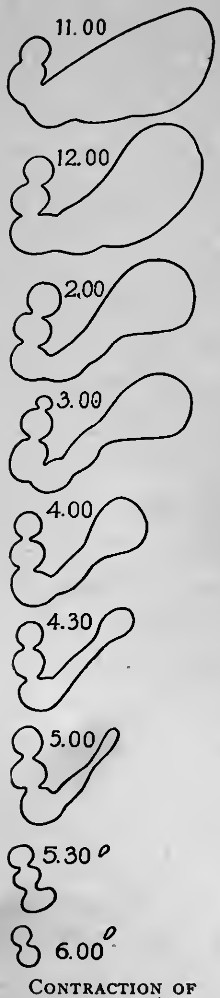
Having made his choice, he took bread, mixed into it a harmless chemical called bismuth,[1] fed it to his cats, and waited for results. The bismuth was put in for only one reason: its presence in the food made it possible to get a shadow of the image of the stomach by means of X rays. From the shadows he hoped to discover exactly how the stomach moves during the time that it is digesting its contents. Dr. Cannon was fortunate in the cats he chose, fortunate in his helpers, and fortunate in what he was able to learn through the X rays; for he learned facts which had never been proved before.

[1] The exact chemical name is bismuth subnitrate.

Under the X Ray. After being fed, at a quarter of eleven in the morning, the cat was put in place for its shadow picture. At eleven o'clock work was well under way in the stomach, and once every half hour after that, until twelve minutes after six in the afternoon, the kindly cat consented to have its shadow studied. Dr. Cannon traced the shadows one by one, so that an exact record was kept of the size of the stomach from the time of the hearty feeding until there was nothing left to be digested.

During this time there was an interesting course of events. When first seen the stomach looked like a small leg of ham with a curled-up tail to it, but when six o'clock came the leg shape had disappeared entirely, leaving nothing but the tail to show where the food had been. Moreover, by this time the cat seemed hungry and called for food, with which it was promptly rewarded.

The Stomach during Digestion. The diminishing size of the stomach was perhaps one of the least important lessons learned that day; for while the cat slept, and while the X rays were focused on its stomach, another fact was noted. It appeared that food which had newly arrived stayed quietly in the upper end of the stomach as if it were in a reservoir. Here the saliva which had been swallowed with the food had a longer time to do its share in the work of digestion. But as fast as supplies were needed farther on, this reservoir contracted itself and sent its contents forward, a little at a time.



CONTRACTION OF CAT'S STOMACH (MUCH REDUCED) DURING DIGESTION

It was also seen that the firm walls of the lower part of the stomach began to contract in a series of wavelike movements. These waves started near the middle of the stomach and moved towards the smaller end of the elastic bag. Every ten seconds a new wave took its start from about the same spot and traveled the same course down to the pylorus at the smaller end.

Indeed, whenever the shadows were studied during the day, these waves were seen to be following each other with unceasing regularity. Moreover, as time passed and as digestion progressed, this middle part of the stomach grew gradually more and more slender, like a neck, while the larger end stayed large for a longer time.

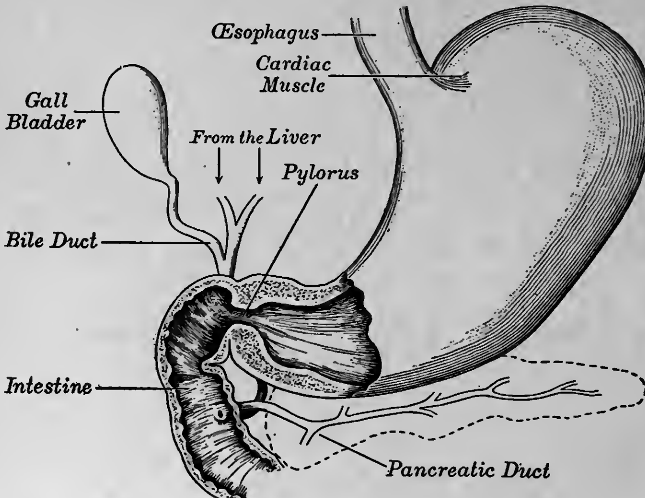
Through his study of shadows Dr. Cannon learned that within about fifteen minutes after food is swallowed a slender jet of softened food goes with a spurt through an opening at the lower end of the stomach and out into the tube which is the beginning of the small intestine.

Entrance and Exit of Food. For all animals, including man, the entrance of the stomach is controlled by what is known as the circular cardiac muscle. This stays closed except when food must enter. The exit for the contents of the stomach is guarded by another strong circular muscle, called the pylorus, or keeper of the gate. And well does this gatekeeper do its work. Sometimes with every wave that rolls in its direction it opens wide enough to allow a spurt of digested liquid food, called chyme, to go through, but sometimes it stays persistently shut while wave after wave pushes in vain in its direction.

Use of Bismuth. To get an explanation of this uneven action of the pylorus, Dr. Cannon induced the cat to swallow a small, specially prepared tablet, made up of starch paste and bismuth. He then watched the progress of this pellet in the stomach. He saw it stay for a long time in the cardiac end; saw it gradually make its way farther and farther down as it was sent forward by the waves of contractions; and finally saw that for forty-two minutes after the pellet reached the pylorus that watchful gatekeeper allowed nothing to pass onward.

Over and over again the pellet and the mass of soft food in which it floated came up to the pylorus as if to demand free passage through, and over and over again the soft as well as the hard was positively rejected and sent shooting backwards, only to come again and again to be rejected.

This was kept up until finally the most fluid of the food was held back no longer. It went onward. Later



THE HUMAN STOMACH

Food reaches the stomach from the mouth through the œsophagus. While digestion goes on, bile runs from the liver directly into the intestine; at other times the opening of the bile duct is shut, and instead of entering the intestine, bile passes into the gall bladder, where it is stored until needed. The outline of the pancreas is shown by a dotted line

the pylorus seemed to give up all protest. It seemed to conclude that there was no hope of ever softening that bismuth and so allowed it to go on in company with food which was properly prepared. The pylorus is indeed a faithful guardian of the food supply.

Undigested Substances. From this experiment it is evident that any hard substance in the stomach is not only slow in passing on through the pylorus, itself, but that it delays the progress of even such food as has already been reduced to chyme — food which should be receiving its next course of treatment in the food tube. The main objection to slow digestion is that after food has stayed too long in the stomach it ferments and gives off gases which stretch the walls of the stomach and cause distress of various kinds.

The next time you eat in a hurry and are tempted to swallow unchewed lumps of food, think of the bismuth pellet and control yourself in time.

Emotions that Hinder Digestion. During the X-ray experiments there came an unexpected turn to affairs one day. Thus far Dr. Cannon had been fortunate enough to have dealings with amiable cats only. They had eaten when he wished, had been quiet and well-mannered during the experiments, and had slept when required. In addition, their stomachs had gone steadily to work when food was put into them and had kept ploddingly at it until digestion was completed.

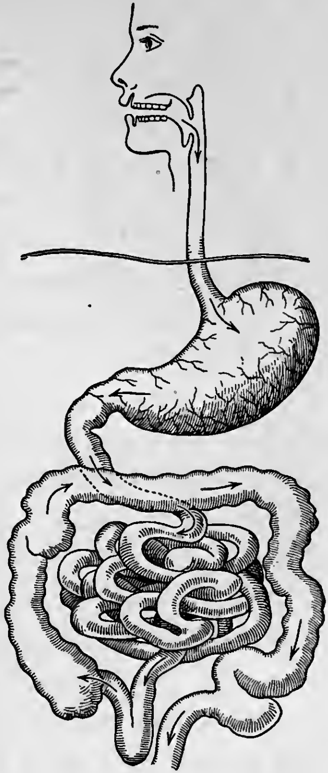
But a different type of cat came to Dr. Cannon's hands one morning. This one ate as promptly as the others, and when the X ray was arranged, the shadow showed at first that the usual regular wave action of the muscular walls was taking place. Suddenly, however, the animal lost his temper. He seemed to feel outraged at what was being done. He refused to purr as did the other cats; he insisted on being released. Being in such a state of mind, he was useless and had to go. But before he was dismissed, the X ray showed that all the waves had stopped; so much so, that the stomach was as inactive as if it were empty.

This led to close observation of the connection between the feelings of a cat and the behavior of its stomach during digestion. Then came the surprising discovery that whenever a cat is unhappy, or disturbed in its mind by anger, anxiety, or distress of any description, the muscular action of the stomach comes to an end.

To prove this conclusively those who carried on the experiments had to tease a well-disposed cat a little, even while it was under the rays. Before the teasing it purred gently, and the wave contractions swept on with rhythmic regularity. But when the teasing began and when the cat felt mental distress every wave ceased; the stomach stopped its work abruptly and absolutely. But if at this point Dr. Cannon stroked the cat, it was at once happy and purred. And with the purring began again the squeezing and the regular progress of the waves along the walls of the stomach.

Happiness and Good Digestion. Doctors have always known that an unhappy man does not digest his food so well as the same man when happy, but none have known just why this is so. It is evident, however, that there is some close connection between happiness and the power of the stomach to keep up the squeezing movement of its waves.

In view of this discovery we plainly see that if we wish good work from our own stomachs we must be neither worried nor anxious nor angry, either during the time that we are eating or as long afterwards as food is in our stomachs waiting to be digested. For the simple sake of health, therefore, the calm and happy mind is greatly to be desired.



THE ROAD THE FOOD TAKES

When to take Exercise. For health's sake never take hard exercise of body or mind just before or just after a meal. Such exercise draws blood away from the region of the stomach just when special supplies of it are needed for digestion. We should have a restful as well as a happy feeling at mealtime, and only by planning for this condition shall we get it.

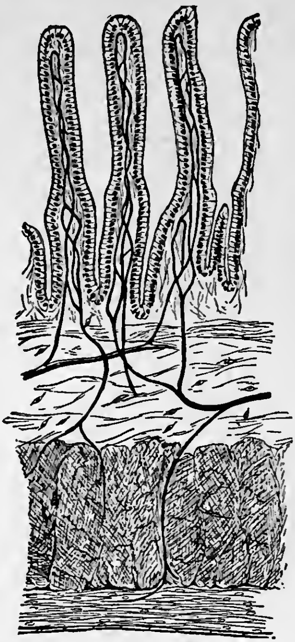
The Digestive Apparatus. The following definite statements are needed for the closing of this section:

1. *The alimentary canal* is the one food avenue of the body. It extends from the mouth downward through the center of the body and is of different size and shape in different parts according to the work it has to do. Throughout its course its walls are controlled by muscles which differ with the kind of squeezing and pulling which is required of them. In addition, the entire alimentary canal is lined with mucous membrane, delicate, pink, and elastic. It is always moist, so that food may move through it easily.

2. *The mouth* is a cavity supplied with teeth for the breaking up of food into bits, a tongue for rolling food from side to side, and saliva for the softening of this food. When ready to be swallowed, the pulplike mass of chewed moist food is laid hold of by muscles at the back of the mouth and forced through the pharynx into the œsophagus.

3. *The œsophagus* extends onward to the stomach. Through it food goes down, not as a stone into a well, but as a package which careful muscles pass along by a squeezing movement. On its way it slides safely over the epiglottis, which has closed down suddenly over the glottis. When the food has passed, the epiglottis lifts and the glottis is open again.

4. *The stomach* is that part of the alimentary canal which has been stretched out into a good-sized pouch. Its entrance is guarded by the strong, circular cardiac muscle; its exit by the pylorus muscle, equally strong and equally circular. While food is in it, the stomach keeps up a constant kneading movement, which sweeps like slow waves from the cardiac to the pyloric end. At the same time gastric glands in the walls of the stomach pour out gastric juice from thousands upon thousands of tiny openings, thus softening still further the food that came from the mouth. When all is as liquid as pea soup the pyloric muscle relaxes, and the prepared stream of chyme shoots its way through into the small intestine. After it enters the intestine the food substance is called chyle.



VILLI THAT FORM THE VELVET LINING OF THE FOOD TUBE

A cut through the wall of the tube, showing some dark blood vessels and four villi

5. *The small intestine* is about twenty feet long, yet it is only a single part of the alimentary canal.

The entire tube is coiled up in compact fashion just below the stomach and the liver, and it expands or contracts with the amount of chyle that it holds.

6. *The villi.* The mucous-membrane lining of the intestine is covered with slender projections called villi, of which much will be said a little later on. They absorb the soluble food for the use of the body. As food passes through the small intestine it grows constantly softer because several fluids are being added to it.

7. *The large intestine and the colon* form the final five feet of the alimentary canal. Here the food continues to be absorbed somewhat and to be passed along until all that is left is sent from the body as waste.

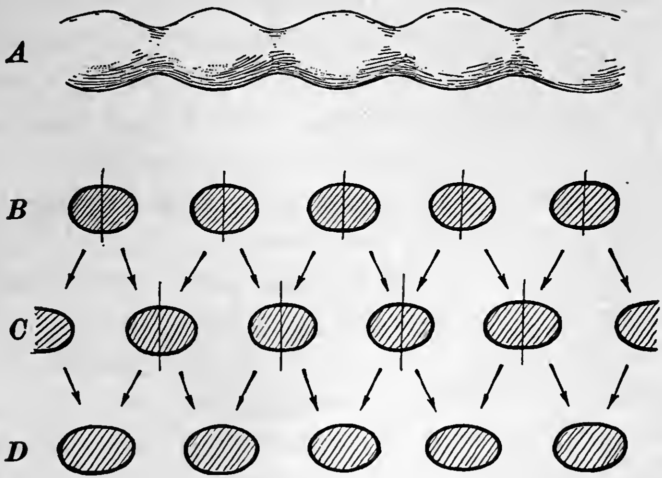
Peristaltic Action[1] and the Villi. Keeping these facts about the canal itself in mind, we are prepared to understand how it is that the food supply in the tube gets into the blood supply of the body. In other words, we are ready to appreciate the wonderful importance of peristaltic action and the villi.

In the same laboratory of the Harvard Medical School, and probably on the identical cats already described, a second set of experiments was made, in order

[1] This means "the peculiar wormlike, wave motion of the intestines, produced by the contraction of the muscular fibers of their walls, forcing their contents onwards."

to determine what is the history of chyme after it has gone through the pylorus into the tube of the intestine and has its new name "chyle."

The entire scientific world was in doubt as to precisely what happens in the tube until, through Dr. Cannon's



THE FOOD TUBE AND ITS CONTENTS

A, the tube as it contracts at regular intervals; *B*, the contents of the tube after the first contraction; *C*, after the second contraction; *D*, after the third contraction. The line through the middle of the oval piece shows where each was divided by the tube as it tightened just there. The arrows show how the new halves were alternately forced apart and driven together by the repeated contraction of the tube itself

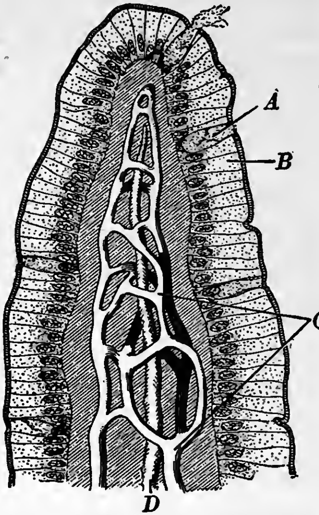
continued experiments, the mystery was explained by the discovery of a series of surprising facts.

Activity in the Food Tube. At first the X rays showed the shadow of the chyle as it lay along in the various loops of the folded tube. All was inactive and quiet for a season. Then came slight warnings — a quiver at first, a mere agitation. Then without further delay, activity began in earnest. The stretched-out length of chyle within an entire loop was suddenly divided into separate bits of equal size. The tube, indeed, without apparent cause, had tightened itself at regular intervals; like a flash it had divided its contents into a series of oval masses of equal size. After this it halted for a moment. But within two seconds there was another contraction, and each bit was now divided through the middle; their halves were compelled to unite with neighbor halves on either side, and a series of new whole ones appeared.

Thus, back and forth, every two seconds, the rapid peristaltic action was continued.

The small masses of chyle were alternately so quickly divided and so quickly forced together again that Dr. Cannon speaks of them as rushing together "with the rapidity of flying shuttles, the little particles flitting towards each other and the larger segments shifting to and fro, commonly for more than half an hour without cessation."

In the meantime the food within the tube was advanced but slowly on its way. It seemed to stay in place for no other purpose than to be acted upon by the squeezing and relaxing of the tube. Whether the chyle was thin or thick, whether the contraction was slow or swift, the squeezing was kept up so unweariedly that each particle of chyle was affected by it. All that lay within the folds and turns of the small intestine was brought into contact with the sides of the tube thousands of times while it was gradually being absorbed. That which could not be used went on into the large intestine, whence it would finally leave the body.



A VILLUS CUT DOWN THROUGH THE MIDDLE

A, a cell which manufactures mucus; *B*, the outside layer, which absorbs chyle; *C*, capillaries to supply each villus with blood; *D*, lymphatic

Relation of Chyle to the Villi. To an ignorant person this endless activity might seem to be a waste of energy and a needless hindrance to the chyle as it is worked along. In point of fact, however, rapid movement of chyle through the food tube would be a distinct disadvantage; for from the time food is swallowed until its journey is ended, the one necessity is that it should be thoroughly prepared to be used by the regiments of threadlike villi which line the small intestine. Chyle, indeed, is improved by every juice that is mixed with it and by every squeeze which it receives before it is absorbed by the villi. So true is this, that food which does not get the treatment it needs will be rejected by each villus which it meets as it travels downward and will end by forming part of the final waste of the body.

Food Waste. With all that we eat there is, of course, much that can never be turned into chyle and blood. We know, however, that this is useful as bulk. But nothing hinders digestion much more, or breaks down general health much faster, than the results which come from retaining waste in the body after it should be sent off. Waste decays in the body just as meat and vegetables decay in the pantry on a warm day. Both in the pantry and in the food tube, decay comes from the action of microbes, and from both places decaying food should be cleared away promptly. The habit of getting rid of waste at a definite hour each day, whether in the morning or in the afternoon, is of priceless value, for that which the villi reject is worse than useless to the body. More is said of this later.

QUESTIONS

1. Describe Dr. Cannon's experiments with cats. 2. Where does the wavelike motion of the stomach begin? 3. Describe the changing shape of the stomach during digestion. 4. How soon after eating does food begin to leave the stomach? 5. Name the muscle that guards the outlet. 6. How does the pylorus act when an undigested substance reaches it? 7. What did Dr. Cannon's experiment prove? 8. Why is

it a disadvantage to have food detained too long in the stomach? 9. What emotions have the power to stop all action of the stomach? 10. What condition of mind helps at the dining table?

11. Describe the alimentary canal; the mouth; the œsophagus; the stomach. 12. Where is the cardiac muscle? the pylorus muscle? 13. Describe the kneading movement of the stomach. 14. What is manufactured by gastric glands? 15. How soft does food get in the stomach? 16. What is it then called? 17. Describe the way chyme leaves the stomach. 18. What is the length of the small intestine? 19. Where is it located? 20. What is chyle? 21. What and where are the villi?

22. What was the object of the second set of experiments on cats? 23. Describe the action of the small intestine as shown by the X ray. 24. How did chyle move through the tube? 25. Is a rapid or slow movement of chyle desirable? 26. What is the work of the villi? 27. Why is chyle squeezed up against them? 28. What becomes of food that is not absorbed by the villi? 29. From the time food is cooked and eaten until its journey is ended, what is all the preparation for? 30. What is each villus like? 31. What is the great object of peristaltic action? 32. What happens if food is not thoroughly prepared for the villi? 33. Where does food meet its final test? 34. What happens to food if it is kept too long either in the pantry or in the food tube?

CHAPTER XI

CHEMICAL ACTION AND DIGESTIVE FLUIDS

The Chemical Fluids of Digestion. No chemist in any laboratory is able to manufacture chemicals quite so marvelous as those the body manufactures to digest our foods. These fluids do two things to the food we swallow:

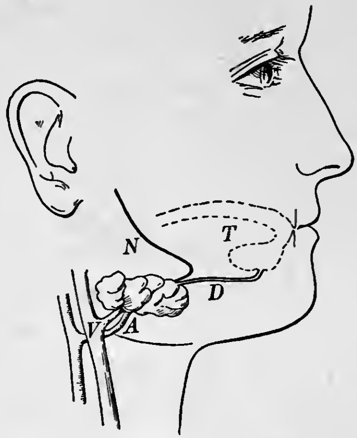
1. They soften it thoroughly and dilute it.
2. They so change it that even substances which will not dissolve in water — beans, potato, bread, and most other foods — are so thoroughly dissolved by digestive fluids that the villi can absorb them.

This chemical process of dissolving food and getting it ready for the villi is called digestion. There are five digestive fluids. Each is manufactured in the body and sent into the alimentary canal, and each does its own special kind of chemical work. Follow them in order, from the mouth downward.

1. *Saliva*, from glands in the mouth. This not only softens food but changes starch into sugar. Try the following experiment: Take a tablespoonful of cornstarch paste. Add a teaspoonful of saliva, mixing it thoroughly with the paste. Keep it at

blood heat for a few minutes. It will not only grow thin and watery, but it will soon have a sweetish taste. The saliva has turned the starch into a kind of sugar. This is easily used by the villi.

2. *Gastric juice*, from gastric glands in the walls of the stomach. In this juice there are three important chemicals — pepsin, rennin, and hydrochloric acid. Rennin turns milk into curd as soon as it reaches the stomach. This is most important, for otherwise the milk would go on through the pylorus without waiting to be digested. After it is turned to curd by the rennin, the pepsin of the gastric juice is able to take hold of it and digest it. Curd is a proteid, and pepsin digests proteids if hydrochloric acid is present. *Gastric juice is the most important proteid digester of the body.*



A Salivary Gland

A, artery; *V*, vein; *N*, nerve; *T*, the tongue; *D*, the tube through which saliva, manufactured by the gland, is emptied into the mouth

3. The remaining three digestive fluids are all found within the small intestine. *Bile*, which comes from the liver through the gall duct, digests fat,

which was simply melted in the stomach. *Pancreatic fluid*, which comes from the pancreas, is a marvel of power. It digests all three substances — carbohydrate, proteid, and fat. *Intestinal juice*, coming from the inside lining of the whole length of the tube, helps do the general digesting. It gives final touches to all food sent down for the use of the villi.

Number and Structure of the Villi. It would seem, then, that from first to last each mouthful of food which we swallow is being put into shape for the villi, and that they use it or not without the slightest reference to our wishes in the matter. This indeed is true, and the number of these independent workers is counted by the hundred thousand and the million. Each separate one is a tiny finger-shaped structure, ready to absorb such chyle as shall meet its demand; each stands beside its neighbor, helping to make the soft velvety lining of the twenty feet of tubing; each does its independent work, yet all are united in drawing nourishment from the chyle and in sending it on to the body through the blood.

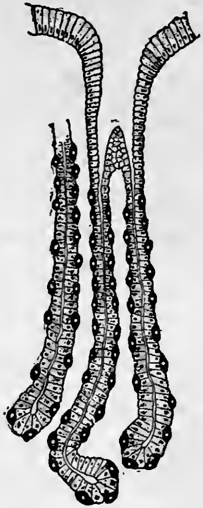
Just here certain facts should be reviewed and condensed:

1. It is through the lining of the small intestine that practically all substances must pass — whether proteid or carbohydrate, fat or mineral matter — which are to enter the blood from the food we swallow.

2. The villi are, in point of fact, the lining itself, drawn up into slender tubes for the sake of increasing the surface against which the chyle must be pressed. They are sometimes called the roots of the body, for they suck up nourishment from chyle just as tree roots draw liquid from the earth.

3. Food passes through the villi much as lymph and plasma pass back and forth through the sides of the tubes that carry blood. This food must therefore be liquid, for the villi cannot absorb any solid substance.

4. The great object of peristaltic action is to wash the chyle up against the villi, so that they may be constantly bathed with fresh supplies of it.



Branches of a Gastric Gland Highly Magnified

Gastric juice is here manufactured for the use of the stomach

5. The mouth with its teeth and its saliva softens food and prepares it for swallowing; the stomach with its gastric juice softens it still further and prepares it for the pylorus; the food tube, with its contributions from the liver and the pancreas, and the juices from its own lining, gives to what we eat its final preparation for the villi.

6. When the chyle which is squeezed against the villi is such as they can use, they absorb it and send it on through other tubes into the current of the blood. When, however, this chyle is not liquid enough, or not changed enough in other ways, they refuse it as firmly as if they knew it would be harmful.

Mistakes in Eating. For each of us almost any well-cooked food can be turned into chyle which will pass through the villi; yet many a thin man, and many a half-nourished woman, shows by every sign of face and figure that the villi are not getting what they can accept.

In almost every such case the explanation lies in some mistake which the person is making. Perhaps he eats so fast and chews so little that the saliva does not have a chance to do its share of work. Perhaps he is so busy just before and just after eating, that blood is drawn away from the stomach, leaving it less vigorous than it should be. Perhaps he worries so much, is so anxious and troubled about many things, that gastric juice fails to form, and thus its part of the work is not done. Or it may be that the unfortunate person has overeaten until his whole digestive system has rebelled. Whatever the cause, we know that we are nourished or starved according as we have been successful or not in preparing the chyle for its last examination. If teeth and tongue, saliva, stomach, gastric juice, bile, and pancreatic juice have done their work well, the final test will be successfully met — the villi will accept the food, and we shall be nourished. If the test is not met, we shall suffer from lack of nourishment.

At this point there arises an important question. Does anything we do ever help or hinder the flow of our digestive juices?

Appetite and Gland Activity. In studying this subject Professor Pavlov, a Russian investigator, fastened a small tube so ingeniously to the mouth of a dog that the saliva ran into it as fast as it was formed. He then made tests and described them, one after the other.

> I now offer this dog a piece of flesh and, as you see, the tube fills up at once with saliva. I stop tempting the dog, hang on a new test tube, and give it a few pieces of flesh to eat; once more a strong secretion of saliva results. A new tube is now attached to the funnel, the dog's mouth is opened, and a pinch of fine sand is thrown in; again there is a flow of saliva. One may employ a number of substances in this way, when a similar effect is always produced.

Flow of Saliva. Many different students have established the fact that the mouths of dogs, and of men too, are supplied with three sets of salivary glands, and that for dogs and men alike one or the other of the two following causes is enough to make saliva flow:

1. A great desire for some special kind of food.
2. The chewing of the food.

Prove these statements for yourself. Think of the most delicious thing you know anything about, and notice the effect on your mouth. Then again, when mealtime comes, take a dry crust and see what you can do with it by the mere act of chewing. Use your jaws vigorously, and before long you will find that you have turned that dry bread into something as easy to swallow as a mouthful of mush.

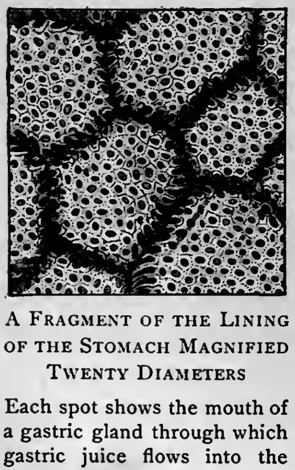
Saliva and Carbohydrate. A wise man with a weak digestion often chooses toast, crackers, and crusts rather than the most delicate custards. He makes this choice because he knows that dry food requires more chewing than soft food, and that for this reason it will receive more from his salivary glands. He realizes that the more saliva we mix with the carbohydrate which we eat in bread, potatoes, and other foods, the better prepared will that carbohydrate be for its next course of treatment. He knows that even after food is swallowed, the saliva will continue to act upon it in the stomach for a season.

We chew food thoroughly for two reasons: first, to soften it; second, to mix it with saliva, which will change some of it and prepare it for its next course of treatment.

Milk Digestion. Carbohydrate does not stand alone in its need of help from the mouth. A baby is allowed to draw no more than the finest stream of milk through the mouthpiece of his bottle, because when milk reaches the stomach it is curdled at once, and it is much better to have it curdle in small flakes, that can be more easily digested, than in one large lump which will be slow in digesting. Young babies who are allowed to drink milk rapidly are not likely to gain so much nourishment from it as they would if it reached the stomach a little at a time. The same is so true for older people too that we should all take our milk in sips and not in a pouring stream which will curdle in a mass as soon as it reaches the stomach. Here the colorless acid fluid, gastric juice, renders priceless service by digesting it.

Proteid Digestion. A dog swallows an unchewed piece of raw meat, and his stomach digests it — not by tearing it to pieces, but in a real way by dissolving it through the aid of gastric juice, his gastric juice being much stronger than ours. Even the human stomach digests unchewed raw meat, but cooked meat needs more chewing. Still it is gastric juice that digests both cooked and uncooked meats. The small gastric glands which manufacture this liquid are packed snugly side by side within the lining of the stomach. Each is supplied with its separate tube, ending in its own special outlet. And the fluid which these hosts of glands secrete and empty into the stomach flows faster or slower according to circumstances. Dr. Pavlov discovered this through his dogs. He found that he could often control the flow by his experiments. Here is one which he describes:

The stomach has been washed out half an hour ago, and since then not a drop of gastric juice has escaped. We begin to get ready a meal of flesh and sausage before the animal, as if we meant to feed it. We take the pieces of flesh from one place, chop them up, and lay them in another, passing them in front of the dog's nose. The animal, as you see, manifests the liveliest interest in our proceedings, stretches and distends itself, endeavors to get out of its cage and come to the food, chatters its teeth together, swallows saliva, and so on. Precisely five minutes after we begin to tease the animal in this way, the first drops of gastric juice appear. The secretion grows stronger and stronger till it flows in a considerable stream. The meaning of this experiment is so clear as to require no explanation; the passionate longing for food, and this alone, has called forth a most intense activity of the gastric glands.



A Fragment of the Lining of the Stomach Magnified Twenty Diameters

Each spot shows the mouth of a gastric gland through which gastric juice flows into the stomach

In carrying on these experiments Professor Pavlov made it plain that dogs should not simply be tempted but should be fed with whatever tempted them.

Effect of Appetite on Digestion. Several other facts were brought out by the same tests. Each was valuable from a scientific point of view, and I give them in close succession:

1. The more eagerly a dog desires food the more gastric juice will flow.

2. Gastric juice flows fastest and longest in connection with food that is enjoyed the most; for some dogs this is raw meat, for others cooked meat. Dogs have preferences as well as men.

3. The mere fact that something is in the dog's stomach does not make the juice flow.

4. The more the juice flows the better will the food digest.

From these important facts, learned through the study of digestion in dogs, men now know why it is that a good appetite helps digestion. Indeed, the call of the body for food — if it is not too long continued — is one of the greatest blessings of life, and he who eats only when he has earned an appetite for food is sure to gain the most nourishment from that which he puts into his stomach, because while it is there it will receive the richest supply of gastric juice.

But aside from digestion itself, there is the great matter of preparing food for the glands even before we eat it.

Why we Cook our Food. Turn back to the food table and decide why we do so much cooking. There are three reasons:

1. *For the sake of health; to make the food more digestible.* Cooking is really a first step in the process of digestion, and there is far more danger that food will be undercooked than overcooked. Take oatmeal and other breakfast foods for example. They contain a good deal of starchy carbohydrates (study the table again), and those who do not understand about cellulose may consider them

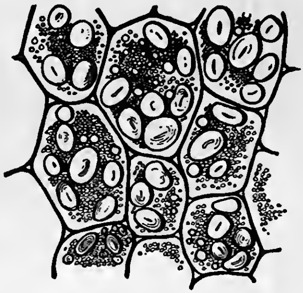
ready to be eaten long before the tiny cellulose cell has been broken up by boiling. An hour of boiling for oatmeal, and half an hour for more finely powdered grains, is none too long. Undigested food ferments easily and produces gas. This is harmful to health.

2. *To destroy microbes* which may be in the food or on it. Recall the facts about this given in *Health and Safety*. Remember that cooking kills microbes, and that a dead microbe is as harmless as a dead lion.

A Bit of Potato, showing Starch Granules

3. *To improve the taste of food.* Glance along the list of foods and think of the difference it makes in the taste of these vegetables, grains, and meats, whether they are cooked or not. Also remember the fact that digestive juices flow fastest when we enjoy our food. Cooking helps us to enjoy it.

Harmful Substances. It is perfectly possible, however, to enjoy what does harm. For years people believed that chocolate and cocoa were good drinks for children, and that tea and coffee were bad for them. Nowadays, however, food experts condemn all these drinks. They say that the same poison is in each drink, and that it stimulates brain, heart, and nervous system. In coffee this stimulant is called caffeine; in cocoa and chocolate, theobromine; in tea, theine. There is more of the harmful substance in tea and coffee than in cocoa, so that cocoa and chocolate are less harmful than tea and coffee, but in every case the stimulant is as bad for tired heart, brain, and nerves as a whip is for a tired horse. Then, too, in tea and coffee there is a substance called tannin. The more the drink is boiled the more tannin it holds. "Puckery" tea contains much tannin and is most objectionable. Tannin is used for the tanning of hides. When we swallow it in tea and coffee we put into the stomach a substance that can disturb the best working of the digestive apparatus. If tea and coffee are made by simply pouring boiling water over them, they contain little tannin, but the caffeine and theine remain.



FROM THE SEED OF THE BEAN
The larger granules are starch, the smaller ones are proteid

Candy and sweetmeats in quantity do harm too, because our digestive apparatus has no device for easily getting rid of large amounts of cane sugar. None of it is digested in the small intestine. If, however, a person is healthy, and if candy is eaten moderately at mealtime, it will do no real harm. But if it is eaten between meals, when the stomach is empty, it becomes an irritating acid in the stomach. The following is quoted:

> A German scientist observed in experiments upon a dog that a solution containing six per cent of cane sugar caused irritation, with reddening of the mucous membrane. A ten-per-cent solution produced a dark-red color, with great irritation, and caused the animal great pain.

From the work of the stomach and of the large number of small digestive glands, turn now to the daily and hourly occupation of the largest glands of the body, our vigilant and untiring protectors, the liver and the kidneys.

QUESTIONS

1. How many digestive juices are there? 2. What two things do digestive juices do for food? 3. Give the names of the chemicals which are in gastric juice. 4. What does rennin do to milk in the stomach? 5. Why is this action important? 6. What does pepsin do to curd? 7. Is curd a proteid or a carbohydrate? 8. What is the most important proteid digester of the body? 9. What three digestive juices are found in the small intestine? 10. Where does bile come from? 11. What does it digest? 12. Where does pancreatic fluid come from? 13. What three things does it digest? 14. What does intestinal juice do? 15. How do the villi help the food to pass through the lining of the small intestine? 16. Why is the lining itself drawn up into these slender tubes called villi? 17. How numerous are they? 18. Why are the villi called the roots of the body? 19. Why does food need to be a thin liquid? 20. What is the great object of peristaltic action? 21. Describe the history of a mouthful of food, from the time we begin to chew it until the villi absorb it. 22. When a person is half nourished, what may be the trouble?

23. Tell what you can about the effect of tempting a dog with meat. 24. How many sets of salivary glands are there? 25. What two things make saliva flow? 26. Why does a sensible man with a weak stomach eat dry toast rather than delicate custard? 27. How does saliva affect starch? 28. After food is swallowed, where does saliva continue its work? 29. Give two reasons why we should chew food thoroughly. 30. Why should babies, and older persons also, take their milk in sips and not in a pouring stream? 31. What can gastric juice do to raw meat? 32. Which needs more chewing, raw or cooked meat? 33. Describe the gastric glands. 34. Describe the tests with dogs which proved certain points about the flow of gastric juice. 35. What should always be done after tempting a dog with food? 36. Under what circumstances does gastric juice flow fastest and longest? 37. What can you say about the advantages of hunger and a good appetite? 38. Give the first reason why we cook our food. 39. How long should we boil oatmeal and other cereals? 40. Give three reasons why we cook our food. 41. Why is it an advantage to enjoy the taste of our food? 42. Why are tea, coffee, cocoa, and chocolate objectionable? 43. Why is much candy harmful?

CHAPTER XII

LARGE GLANDS: THEIR USE AND ABUSE

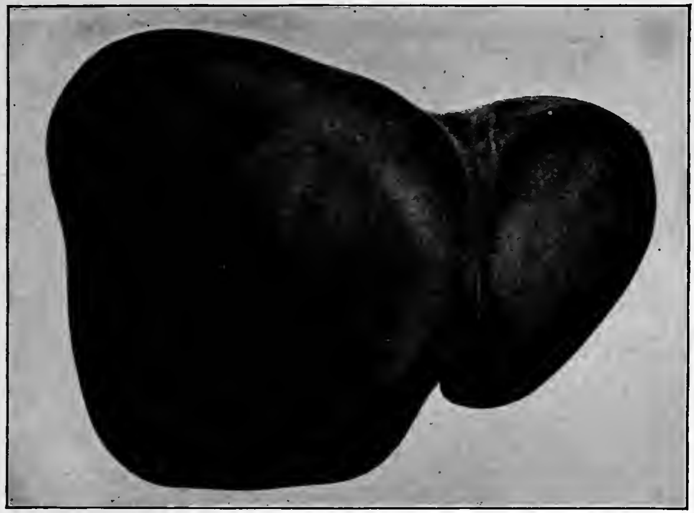
The Liver — what it Is and what it Does. If you are thin enough to do it, you might slip your fingers up under the edge of your lowest ribs on the right side. There you will feel the outline of the largest gland in your body. The liver weighs between three and four pounds, and it is to this organ that the villi send much of that which they draw up from the chyle.[1] The following are the occupations of the liver:

1. It changes part of the liquid food which it receives from the villi into a sugar substance called glycogen. It stores up this glycogen in its own liver tissues and keeps it there until it is needed for the work of the body. The liver is thus a glycogen storehouse, a bank of deposit.

2. It takes certain wastes from the blood, makes them over, and forwards them to the kidneys in the blood stream, to be sent from the body by the kidneys.

[1] Part of the food supply which the villi gather from the small intestine — especially the part that holds digested fats — does not go direct to the liver. Instead, it travels upward first and reaches the heart by the way of the neck.

3. It manufactures bile as needed. This is sent through the gall bladder and the bile duct into the small intestine. There it helps digestion and afterwards escapes with the other wastes of the alimentary canal. Into the bile go certain captured



As the Normal Liver looks

(After Horsley)

poisons. For example, if peas or pickles colored with copper are eaten, the liver seizes the metal, sends as much as possible into the bile, and stores up the rest within its own cells. It does this to keep the poison from getting into the blood stream and going to the rest of the body. It is only when there is too much poison for the liver to manage that it escapes into the general blood stream and becomes a menace to different organs of the body. So also with other poisons. In a very real way the liver is our daily protector from death by poisoning.

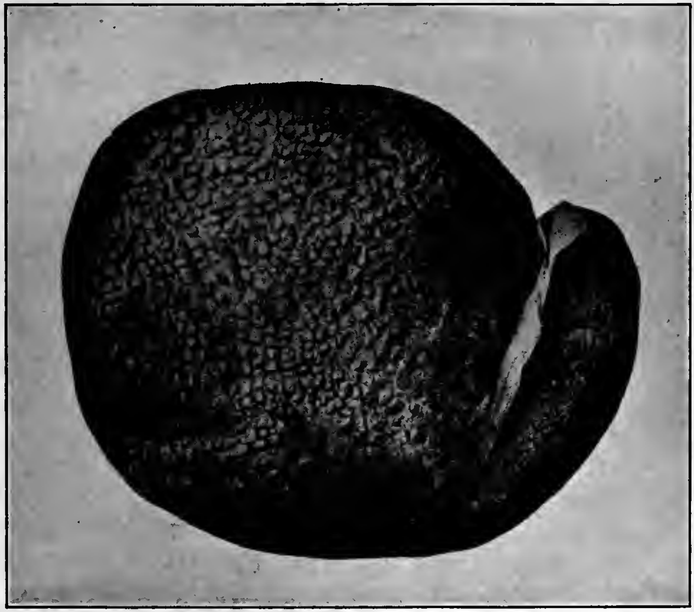
Clearly enough, no man who knows the facts and who wishes to make sure of his health will care to ignore the welfare of his liver or to act as if he were ignorant of the laws which control it. Nevertheless, many of the discoveries about these laws are so recent that even some well-informed people have failed to hear about them.

This is true of my neighbor who complained about his liver the other day. He said the doctor advised him to eat less, to exercise more, and to give up his beer until he was in good shape again. But against this he protested. He said, "Can't I judge what is good for me by my own feelings?" The doctor said he could not, and the doctor was right. Follow the argument closely.

Effects of Alcohol on the Liver. Those of us who have ever seen a piece of raw liver know how extraordinarily bloody it is. We also know that every piece of liver is always deluged with its own blood. This is inevitable, because the liver is provided with an enormous number of small blood vessels, each one of which is in active service.

When, therefore, the doctor gave my neighbor that advice about beer, he was advising according to his knowledge of the effect of alcohol on blood vessels in general.

He knew that wherever there is an unusual supply of capillaries and blood-carrying tubes of all sizes, there will alcohol do its paralyzing work. He knew that when blood vessels in the liver are somewhat paralyzed and

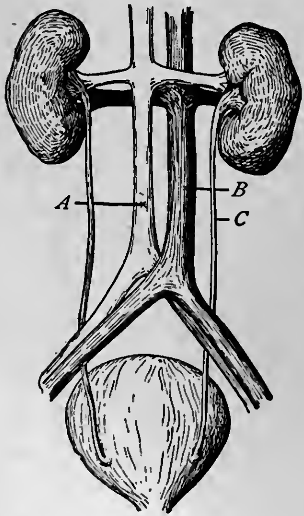


A Drunkard's Liver ruined by Alcohol

(After Horsley)

enlarged beyond their usual size, the liver itself is sure to suffer in a serious way.

When a doctor examines liver after liver as he finds them in the hospital and in the dissecting room, he counts the ignorance of the unfortunate men no laughing matter. "A drunkard's liver again," he will say as he opens up the telltale gland. "No wonder the man died. It's a wonder he lived as long as he did, with a liver of this sort to purify his blood supply for him. It has swollen to twice its natural size. The tubes are distended and inactive; the cells are loaded with fat." Any such inactivity prepares a man to fall an easier prey to microbe diseases and to die earlier than he might have died. Life-insurance societies know this so well that some of them charge even the moderate drinker more for the same amount of insurance than they charge the non-drinker.

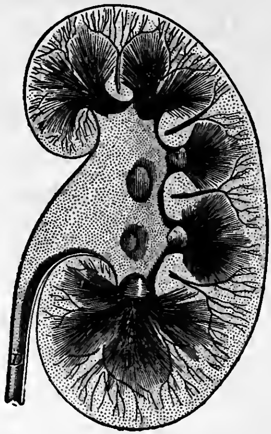


THE KIDNEYS AND THE BAG WHICH THEY SUPPLY WITH WASTE WATER

A, artery; *B*, vein; *C*, tube through which water leaves the kidney

The Kidneys — what they Are and what they Do. Two other glands coöperate with the liver as protectors of the body. These are the kidneys. They lie on each side of the lower part of the back, and their structure is a marvelous arrangement of closely packed microscopic tubes which are netted about by vast numbers of capillaries. They weigh from four to six ounces apiece. Their special work is to remove poisons and wastes that accumulate in the blood. All this waste is then sent, as a liquid, through two slender tubes into the bladder. Thence, by another tube, it leaves the body.

In view of what they do, the kidneys may well be called the life preservers of the body. For after stomach, intestines, villi, and liver have done what they can for us, the left-over wastes and poisons are finally thrown upon the kidneys for disposal. If, then, the kidneys fail us, the outlook for the body is serious indeed. Brain, muscles, glands, arteries, and veins will now suffer because, one and all, they draw their supplies from an impure blood stream.



A CUT THROUGH THE KIDNEY

Notice the clusters of slender tubes; each separate one might be called a *laboratory*

Effects of Alcohol on the Kidneys. When, therefore, the jovial drinker pours his beer and his whiskey into his stomach, let him remember that the alcohol of that drink will pass quickly into his blood, that within a few minutes it will find its way to the cells and the tissues of his life-preserving kidneys, and that, in course of time, those tender tissues will become inflamed and less able to do even so much as their usual work. Nevertheless, while in this condition, there will pour upon them not only the alcoholic blood itself to be grappled with but all the unconquered wastes and poisons which the overworked liver could not eliminate. The struggle will keep on for a season. Unpurified blood will grow more and more impure, until both the liver and the kidneys are overcome at last. When this happens the doctor may say: "You are suffering from auto-intoxication. Your whole system seems to be out of order, but the main trouble is with your liver and your kidneys. They seem to be literally worn out."

Auto-intoxication. When a doctor speaks of auto-intoxication — and most of them do it nowadays — he means that the body is being injured by poisons made within itself. As it happens, a great part of these poisons comes from certain microbes which multiply within the intestine. Some of them are really harmless. Others are known as the putrefactive microbes. They live mostly on the proteid foods in the intestines, and as they multiply they produce poisons which in some cases are most detrimental to the body. Nevertheless, these poisons — toxins, they are called — are sucked up by the villi along with the useful food and are sent to the liver to be poured into the general blood supply. Imagine, then, the work which is forced upon the liver as it tries to take the toxins from the blood stream. What the liver cannot attend to, the kidneys must remove. If both these organs have been damaged by alcohol, or by any other cause, they cannot do full work. The blood is then not cleared of poisons as it should be, and the result is auto-intoxication. This shows itself in headache, irritability, or discomfort of one sort or another. Serious illness may follow, just because a weakened body is at a disadvantage when disease microbes attack it:

How to prevent Auto-intoxication. There are three ways to prevent auto-intoxication:

1. *Be mindful of the liver and the kidneys* and do not put into the body any food or drink which may weaken the power of either. Even when these organs are in their best condition, they have about all they can do to save us from auto-intoxication. Do not lessen their power to serve you.

2. *Avoid much animal proteid.* This decays faster than vegetable proteid in the alimentary canal, and the faster the decay the more the putrefactive microbes multiply. Think how much sooner meat spoils than beans. Guard yourself against alcohol, against tea and coffee, and against all highly seasoned foods. Also eat sparingly of the following articles: pies, soggy dumplings, rich cake, doughnuts, and everything soaked in frying-fat. All are more or less indigestible. If you ever eat them, therefore, do thorough chewing before the swallowing. Turn them into thin paste in your mouth. When taken in this condition they do less harm.

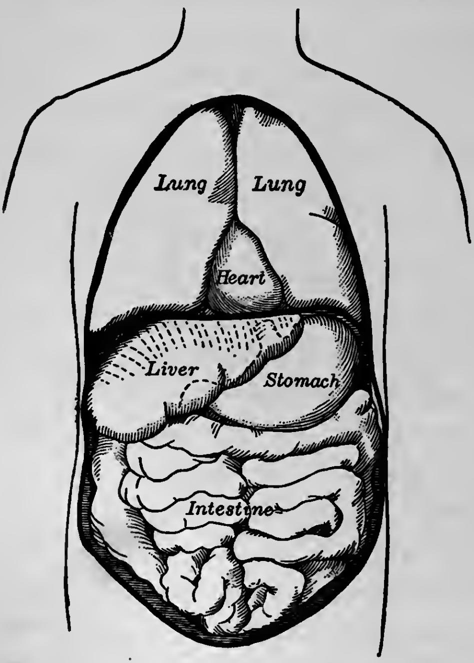
3. *Get rid of waste* from the large intestine every day. Food waste should pass through the entire length of the alimentary canal within from sixteen to twenty hours after it is swallowed. If waste is not fully cleared away, it acts like a poison to the body. We then say the person is constipated. In this condition the body is threatened, for microbes in the intestine are multiplying in constantly swarming hosts, and auto-intoxication is almost sure to result. As a rule take no medicine for constipation. Instead, take regular exercises that make the muscles of the abdomen work hard, and eat graham or bran bread — or even a tablespoonful of bran itself — with every meal. One may buy this from any grocer. Bran helps by giving bulk for the intestine to act upon. Eat freely of lettuce, celery, vegetables, and fruit. Be sure to drink the needed three pints of water every day.

4. *Avoid tainted food.* So-called ptomaine poisoning often follows the eating of tainted meats. And thousands of babies die because their milk food is spoiled by microbes. This is why we insist on having fresh meat and clean milk.

Headache and Auto-intoxication. It should be stated clearly that headache is more often due to auto-intoxication than to any other one cause. (Headache from eyestrain is spoken of later.) To get rid of the pain, clear the body of its waste. Also, for immediate relief, wrap a hot, wet towel about the face and the back of the neck. This expands the capillaries and draws blood from the brain. Never take drugs unless everything else fails and the doctor orders it. The drug habit is easily formed, and it is a fearful master.

Other Glands. The same damaged blood which hampers the liver and the kidneys, giving us headache and other ills, is also a disadvantage to every other gland of the body. Each is a mass of soft tissue made up of separate working cells. In size our glands vary all the way from the four-pound liver to the smallest sweat gland in the skin. The product of any gland is called its secretion. Some glands send their secretion through a duct to its destination. For example, the surface of the body receives sweat secretion from the sweat glands. The eyeball receives a secretion from the lachrymal glands. Five other sets of glands — about which we have already studied — send their secretions into the alimentary canal. Still other glands are called ductless. These ductless glands send their secretion directly into the blood as it passes through them. They have no need of any duct. Nevertheless, what they manufacture is of vital importance to the body. Among ductless glands are the two thyroids in the neck. When these are diseased, people often suffer from what is known as goiter. But whether glands have ducts or not, a damaged blood supply is a disadvantage to them all. This is part of the reason why tight clothing is so objectionable.

Ill Effects of Snug Garments. The fashion for small waists comes and goes, but harm comes and stays even when the pressure of the lacing is not very great. Imagine some new kind of X ray that could show what lacing does to different parts of the body. Here are the items of damage:

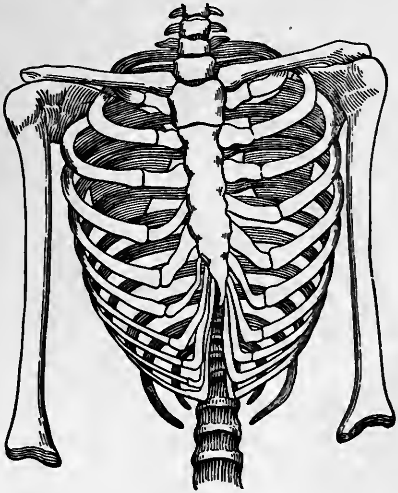


Inside Organs before the Lacing

1. The liver is forced into such small compass that its capillaries and tiny tubes are hard-pressed upon. Thus crowded they cannot do good work in preparing needed glycogen for the body. Neither can they fully purify venous blood of its waste. As a result, unpurified blood goes on its way, carrying danger to all parts of the body.

2. The stomach is so crumpled up and crowded that indigestion follows, than which nothing is more fatal to a beautiful complexion.

3. The long folds of the small intestine are pushed downward, and are so pressed upon that the entire tube becomes inactive. Food moves slowly through it, and as this food decays, gas is formed and toxins multiply. This gas stretches the walls of stomach and intestine alike, and pain follows.



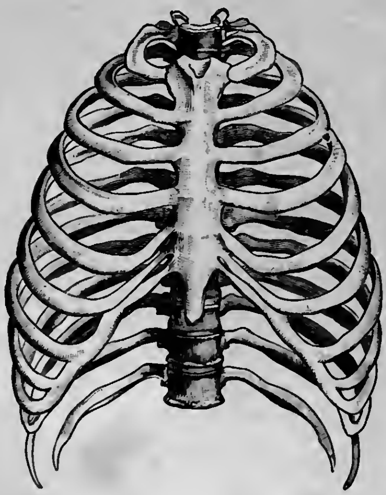
RIBS OF A YOUNG WOMAN WHO DIED AT THE AGE OF TWENTY-THREE. SHE LACED

(After Tracy)

4. After lacing has gone on for some time the muscles which make up the walls of the abdomen become relaxed and flabby through lack of exercise. As a result, the organs which these muscles should hold in place are left sagging downward. After this each organ has to carry on its business as best it can under most unfavorable conditions. If illness follows, the suffering person should blame no one but herself.

5. Lacing so cramps the lower lung cells that multitudes of air sacs are wholly out of service and breathing has to be done through the lifting of the chest — not through the better way of spreading out the ribs. How loose then should our clothing be?

Importance of Loose Clothing. Stand with your back to the wall, with head, heels, and elbows touching it. Now draw a deep breath. Can you do this without feeling that bands, strings, buttons, or hooks are being pulled rather vigorously? Our clothing should always be loose enough to allow us to breathe freely. Bands should never bind the waist, and the weight of heavy clothing should be carried by straps that hang from the shoulders.



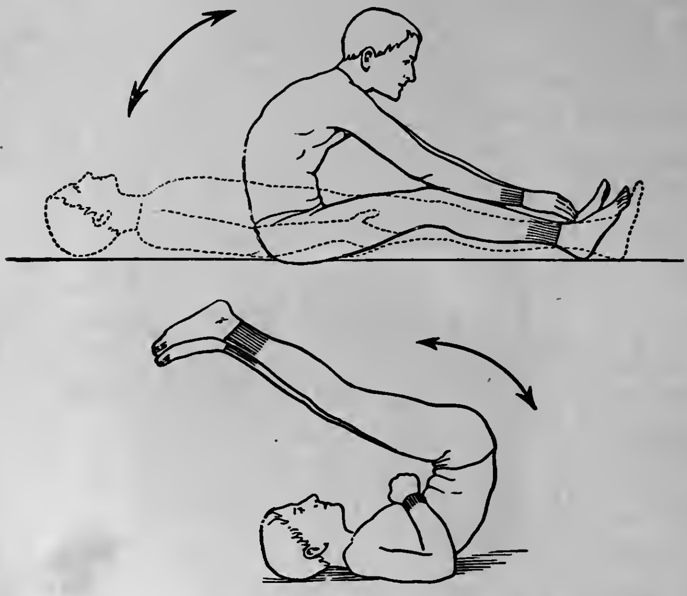
THE SHAPE THE RIBS SHOULD HAVE

Remember that the more easily the gland laboratories are allowed to do their work, the better able are we to endure the wear and tear of life and to resist disease of every sort.

The Two Body Cavities. In a way it may be hard to think of the trunk of the body as a double-story set of

THE DIAPHRAGM WHEN IT IS RELAXED

The organs from above it and below it have been removed apartments, but such it is. For, stretching across us from side to side, a little above the waistline, is a strong, broad, elastic partition of muscle, called the diaphragm. Below it, in one cavity, lie liver, stomach, intestine, and other



Exercises to strengthen the Muscles of the Abdominal Wall

(After Schmidt)

important organs; above it, in another cavity, are the heart and lungs, with the large and small tubes which belong to them. Through the diaphragm go a large artery, a large vein, and the tube which carries food from the mouth to the stomach.

Above the diaphragm, then, we find the organs of respiration and circulation; below it lie the organs of digestion and the great gland, the liver. Above the diaphragm, blood is ridding itself of carbon dioxide; below the diaphragm, blood is getting supplies of nourishment to carry to the tissues of the entire body.

The Rhythmic Movement of the Diaphragm. But what active share does the diaphragm take in all this? Draw a deep breath. As you do this, you are not only raising your ribs but also contracting your diaphragm from every side, taking the arched shape out of it, and forcing it down upon the organs below. Each breath gives those lower organs good exercise, for the diaphragm is the largest and the strongest breathing-muscle we have. When it contracts, air rushes down into the lungs. When it relaxes into its normal arched shape the pressure is lifted, air rushes out of the lungs, and the upper cavity is smaller again.

Liver, stomach, and intestines all gain vigor from the rhythmic movement.

Aid to the Organs of Excretion. The rhythmic movement is important because our organs of excretion need the exercise that it gives them. These organs are the lungs, which get rid of carbon dioxide; the small and large intestines, which rid us of food waste; and the kidneys, which rid us of waste water and its poisons. The skin is the fourth great organ of excretion. It helps the kidneys through its discharge of perspiration and will be discussed later.

Notice the difference between *excretion* and *secretion.* Excretion is waste from the body. Secretion is something manufactured by an organ of the body.

QUESTIONS

1. Name the largest gland in the body. **2.** Give its position; its weight. **3.** Mention its three kinds of work. **4.** Through what duct does bile go to the small intestine? **5.** What kind of waste goes into the bile? **6.** Why does the liver store up certain substances in its own cells? **7.** When it cannot store it all, what becomes of the rest? **8.** What does a doctor advise men to do when they have liver trouble? **9.** Why is a piece of raw liver bloody? **10.** Why is alcohol especially harmful to the liver? **11.** What often happens to the liver through the use of alcohol? **12.** What do life-insurance societies do about charging drinkers for their insurance?

13. What other glands are greatly affected by alcohol? **14.** Give the location of the kidneys; their appearance; their weight. **15.** What is their special work? **16.** Where do they send their waste? **17.** If they fail in their work, what parts of the body will suffer? Why? **18.** Mention facts which those who use alcohol should remember. **19.** Besides alcohol, what other substances will reach the kidneys in the blood stream? **20.** When liver and kidneys are overcome, what will the doctor probably say?

21. What is meant by auto-intoxication? **22.** What are putrefactive microbes? **23.** Where do they multiply? **24.** What do the villi do with the toxin which the putrefactive microbes manufacture? **25.** What does the liver do with these toxins when they reach it? **26.** If the liver cannot take them all out of the blood, what must the kidneys do? **27.** If both the liver and the kidneys have been damaged by alcohol, or by any other cause, what happens to the blood? **28.** Mention three ways by means of which one can prevent auto-intoxication. **29.** Why is it necessary to keep the body well cleared of its waste substances? **30.** How much water should we drink each day? **31.** Which decays faster in the alimentary canal, animal proteid or vegetable proteid? **32.** Why should we reduce our supply of animal proteid?

33. What are the manufacturing organs of the body? **34.** What is the structure of each gland? **35.** How do they vary in size? **36.** What is the product of a gland called? **37.** Mention different ways in which glands send off their secretion. **38.** What secretion, from what glands, is poured out on the surface of the body? **39.** What glands supply the eyeball with moisture? **40.** How many sets of glands send their secretions into the alimentary canal? **41.** What are ductless glands? **42.** How does their secretion get into the blood? **43.** When thyroid glands are diseased, what is the name of the disease?

44. What happens to the liver when a person laces? **45.** What is the effect of lacing on the stomach? on digestion? **46.** How does lacing hinder the work of the small intestine? **47.** Why do the walls of the abdomen become relaxed and flabby? **48.** Is this an advantage or a disadvantage to the work of the internal organs? **49.** What does lacing do to the lower lung cells? **50.** What is the diaphragm? **51.** What organs are above the diaphragm? below it? **52.** When relaxed, what shape does it take and what happens to the air in the lungs? **53.** Name the organs of excretion. **54.** Define excretion; secretion. **55.** How loose should clothes be about the waist? **56.** If gland laboratories and the diaphragm are allowed to do their work freely, what will be the result to the body?

CHAPTER XIII

WHY NATIONS RID THEMSELVES OF ALCOHOL

France and the Liquor Problem. On the eighteenth of December, 1902, in the city of Paris, France, a report was made by a committee of the government. The state officials considered this report so valuable that they ordered copies of it to be printed as posters in large black letters on a white background.

These posters were placarded here and there on the important buildings of the city. They were put on the walls and in the corridors of hospitals, on the streets, in the post offices, and even on the outside wall of the great Hôtel de Ville, where the business of the city is carried on.

A few extracts will show what it was that the government wished to proclaim in this public way.

DRAFTED BY

PROFESSOR DEBOVE, Dean of the Faculty of Medicine
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Alcoholism is chronic poisoning, resulting from the habitual use of alcohol, even when this is not taken in amounts sufficient to produce drunkenness. Alcohol is useful to nobody, it is harmful to all. It leads, at the very least, to the hospital, for alcoholism causes a great variety of diseases, many of them most deadly. It is one of the most frequent causes of consumption. Typhoid fever, pneumonia, or erysipelas, which would be mild in a sober individual, will rapidly kill the alcoholic. Alcoholism is one of the most frightful scourges, whether it be regarded from the point of view of the health of the individual, of the existence of the family, or of the future of the country.

After the beginning of the great war in 1914 France went even further, and absolutely prohibited the manufacture and sale of the intoxicant, absinth.

The German Attitude. Nor does France stand alone in this protest. Even as long ago as 1908 Germany had already printed 871 books that discussed the question of alcohol. At that time 37 German newspapers, magazines, and annuals devoted themselves to the same subject, and hundreds of articles about alcohol were printed in the important magazines of that country. In 1907 one hundred leading professors in German universities signed a declaration which included the following statements:

> All prevalent ideas in regard to the invigorating and otherwise supposedly beneficial properties of alcohol in small doses have been proved erroneous by scientific research. Moderate drinking has a tendency to make the human body more liable to disease and to shorten life.

With this testimony before them, we are not surprised to learn that in 1915 — for the sake of guarding German soldiers and German workmen from inefficiency — the supply of beer in Germany was cut down 60 per cent.

Russia and Prohibition. In Russia, in 1914, when the war began, orders were issued that thenceforth there should be absolute prohibition of alcoholic drinks. This meant that in a country where 150,000,000 people had been using all the liquor they cared to pay for, no more should be either manufactured, bought, or sold. In describing what was done, Professor Helenius Sepälä of the University of Helsingfors, Finland, says:

On the sixteenth of October, 1914, all the old stock of ale in the beer shops was, by order of the authorities, poured out on the ground. . . . Everywhere in Russia, including Siberia, the Caucasian provinces, Courland, etc., the sale of distilled liquors and strong wines is strictly prohibited. . . . I walked about the capital one day after another, stepping into restaurants both in main streets and in side lanes, and feeling like a dreamer because the sights I had formerly seen everywhere in the Russian capital I now no longer saw. . . . I did not see drunken men and women, I did not find whiskey or vodka anywhere. There were great festivals going on, the streets were filled with people overpowered by their patriotic emotions, it being the birthday of the czarevitch, but all the time I did not see a single person the worse for liquor.

Another writer says:

On account of this prohibition, crimes have diminished so much in Russia that the planned building of new prisons has had to be interrupted. Physicians tell us that the number of patients in the hospitals has decreased considerably and that the alcoholistic polyclinics in Petrograd are now practically without anything to do! On the other hand, the officials of the savings banks have been compelled to ask for increase of their number, in some places double, on account of too much work, and the number of depositors has, in spite of the war times and unusual difficulties, increased enormously.

The English Method. In England they are trying to reduce the consumption of liquor by greatly increasing the taxes on it and by giving the government full power to control the saloons in places where war material is being produced and transport work done.

The Japanese Liquor Law. In Japan the law of the land forbids the sale of alcoholic drinks to those who are under twenty years of age.

The Movement in America. In the United States of America, in 1915, 520 daily newspapers and 63 important magazines refused to print any advertisement of whisky, beer, or other alcoholic beverage, and the number of such papers increases with each month. These statistics were gathered by the Temperance Society of the Methodist Church.

In 1915 the new rule of the Carnegie Steel Works, Pittsburgh, Pennsylvania, declared that promotion was only for total abstainers. In 1915, also, the head of the Health Department of New York City declared that the entire power of the board would be used to "fight the rich man's champagne as well as the poor man's beer." The statement was then made that "it is as necessary to battle drink as to fight an epidemic."

The United States Department of Labor has investigated the subject of alcohol in connection with the employers of skilled labor. It finds that already 72 per cent of the farmers, 88 per cent of the trades, and 90 per cent of the railroads make positive discrimination against the man who uses alcohol. For example, Marshall Field and Company, of Chicago, say: "Any man in our employ who acquires the habit of drink, even though moderately, is to a certain extent marked down in our estimation, and unless we can remove from him this serious fault and show him his error, we feel compelled to do without his services." Employers of labor discriminate in this way because they cannot afford to pay for the services of a man who is below par physically and mentally.

And what of skilled laborers themselves? On May 25, 1915, in Cleveland, Ohio, the Brotherhood of Locomotive Engineers passed the following resolution by unanimous vote: "Be it resolved that this Brotherhood of Locomotive Engineers go on record as favoring state-wide and nation-wide prohibition of intoxicating beverages." There were present 819 delegates, who represented 74,000 engineers in all parts of the United States and Canada. Afterwards one of them said: "Engineers of America have been trained for years to understand that drink and efficiency do not run hand in hand. If any one needs a clear head it is the man in the cab."

Nor is this all. Great nations and great bodies of voters are not the only ones who are voting themselves free. Smaller nations are equally anxious for safety.

The Island of Newfoundland. During December, 1915, Newfoundland voted four to one in favor of prohibition for the entire island. The count stood 24,965 votes for prohibition and 5348 votes against it.

Taxes, Crime, and Poverty. No doubt thousands of citizens in every land have in mind the taxes which they must pay to help support the poorhouse, the courthouse and jail, the reformatory, the insane asylum, the orphans' home, and the police force of every state and city. In these days we all know that the larger part of the occupants of these institutions are where they are because they themselves or their ancestors used alcohol as a beverage. Mr. Henry M. Boies, who studied the subject for years in America, said that the crime committed in the United States costs at the rate of $6.20 a year for each man, woman, and child in our country, and that alcohol's share in the expense of this crime is about $4.34 for each person. Drunkenness alone, he tells us, costs the United States $420,000,000 a year.

Statistics for London, England, show that this one city pays $5,000,000 a year for the expense of its drunken paupers.

To show the difference which alcohol makes in the taxes of license and no-license towns, glance at the following figures. They are compiled from the reports of the United States Bureau of the Census on municipal revenue expenditures and public property for 1913.

GENERAL PROPERTY TAXES COLLECTED

Prohibition states	$10.12 per capita
Near-prohibition states	$11.08 per capita
Partially license states	$14.32 per capita
License states	$16.98 per capita

When you see a drunken man arrested, or read of men taken to jail or to the hospital because they have damaged themselves or other people by using alcohol, you might say to yourself, " My honest, hard-working father, through his taxes, helps pay for arresting the man, for trying him, for taking care of him in prison, for feeding and clothing him while he is there; and if the man dies in the place, my father must help meet the bill for his burial."

Fortunately the entire world is wakening to the serious harm which alcohol does to society in every way, and this explains the dawning era of prohibition.

QUESTIONS

1. Tell how Paris began to attack its liquor problem. 2. When did France prohibit the manufacture and sale of absinth? 3. What had Germany done before 1908 about the alcohol question? 4. What declaration did the leading professors of Germany make? 5. How much was Germany's beer supply cut down in 1915? 6. What orders were issued in Russia in 1914? 7. How many people did these orders affect? 8. What did Professor Sepälä say about the results of this action? 9. What effect did prohibition have on prison building? on the number of patients in the hospitals? 10. What did England do to reduce liquor

consumption? **11.** What is the liquor law in Japan? **12.** Tell what you can about liquor advertisements in papers and magazines in the United States in 1915.

13. Give the rule of the Carnegie Steel Works about promotion. **14.** When the United States Department of Labor investigated the subject of alcohol in connection with the employers of skilled labor, what did it find? **15.** Why do employers of labor object to those who use alcohol? **16.** Give the resolution of the Brotherhood of Locomotive Engineers. **17.** What was the result of the vote on prohibition in Newfoundland? **18.** Why are taxes high in countries that use alcohol? **19.** What sends many people to the poorhouse, the jail, the insane asylum, and the orphans' home? **20.** Give Mr. Boies' statement about the cost of crime in the United States. **21.** What is London's annual expense for drunken paupers? **22.** What is the difference between property taxes in prohibition states and in license states? **23.** In what way does every honest man help support those who are criminals and worthless?

CHAPTER XIV

BODY TEMPERATURE AND THE SKIN; OR WORK, HEAT, AND FUEL

Testing the Effect of Heat on the Body. There is no doubt about the value of the work which certain scientists did in 1775. These men were anxious to know how much heat the body of man can endure and still keep at its work. For the sake of making no great blunder, they began their tests by passing from one heated room to another until they found themselves living and breathing in a room in which the thermometer showed a heat of 210° F. This is but two degrees cooler than the temperature which water needs for boiling.

As may be imagined, the air of the room felt very hot. One man, however, stayed in it for ten minutes. During this time the heat was so great that it twisted and broke the ivory frames of all the thermometers but one. More than this, the air which the man inhaled was so much hotter than that which he exhaled, that with each breath which he drew he felt as if he were scorching his nostrils. But with each exhalation his nostrils were cooled again. He took the thermometer in his hand and blew on it. At once the mercury sank in the tube, showing that his breath was cooler than the room. He blew on his fingers, and they were cooled too.

In another experiment, afterwards, the same men went into a small room which was even hotter than any they had been in before. Here the thermometer showed 260° F. This, then, was forty-eight degrees hotter than water needs for boiling. As they entered the air felt hot, but they could bear it. And while they stayed there, they did various things to show what the heat of the room was able to accomplish. They took a piece of raw beefsteak, left it uncovered, took a pair of bellows, blew the heated air across the steak for thirteen minutes, and found that it was rather overcooked. An egg was roasted hard in twenty minutes; water soon boiled and bubbled; watch chains became too hot to be touched; and rings had to be left off, lest the heated metal should burn a deep circle about the tender flesh of the finger. Leather shoes could not be worn, for the leather itself curled up and was ruined.

Sweat Glands as Protectors. All this happened to their possessions, but the men themselves, although surrounded by the same heated air, were neither boiled nor roasted. They lived and breathed in the place, escaped alive, and their escape was no miracle. It was explained by the power of the sweat glands. If these small laboratories had stayed inactive the scientists might have suffered from the heat even as did the steak.

As soon as the men entered the heated room the sweat glands began their work and perspiration was manufactured in quantities; it poured from the open flues of countless small laboratories and emptied itself upon the skin, whence it was evaporated. Thus perspiration kept the skin moist, and the evaporation of the moisture kept the surface of the body cool enough to save it from being cooked. Certainly the men were uncomfortable from first to last, but they did not suffer.

A Sweat Gland and its Outlet on the Skin

The record of these experiments is given in the *Philosophical Transactions* of the Royal Society of London for the year 1775.

If you ever have the chance, watch the streaming, steaming backs of such men as pitch coal into the huge furnace of an ocean liner. There you will see the same work of protection carried on by these tireless glands. Their exact number is unknown, but by counting a few in a small area of the skin, and by multiplying this number by the extent of the surface of the body, men estimate that each of us is supplied with about 2,000,000 sweat-gland laboratories. All are slightly busy most of the time, but are only extraordinarily busy when emergencies overtake the body.

Important Facts about the Skin. Just here, review your knowledge of the skin and of perspiration.

1. The outside layer of the skin is called epidermis. It can be cut or pricked without giving pain. It protects all that lies underneath it, in the second layer of the skin.

2. The second layer — the dermis — holds countless capillaries, also nerve fibers, hair cells with their muscles and oil glands, sweat glands, and pigment cells. These last contain coloring matter — pigment — which gives one boy freckles and another boy tan; which makes one man brown and another man yellow. Both nails and hair are constantly being formed in the dermis and pushed upward.[1]

3. Perspiration is a mixture of water and waste. It is poured out by the sweat glands when the body is heated or exercised. The

CUT THROUGH THE LAYERS OF THE SKIN

A, horny layer of epidermis; *B*, deeper layer of epidermis; *C*, duct of sweat gland; *D*, dermis; *E*, connective tissue in which the black lines represent blood vessels

[1] Full directions about the care of both are given in *Health and Safety*.

water soon evaporates and cools the skin. The waste stays on the skin and must be washed or rubbed off; otherwise it mixes with oil from the oil glands, with bits of epidermis, with dust from the clothes and from the air, and stays like a snug, thin, perfectly fitting coat on the outside of the body from head to heel. A wrap of this sort interferes with the healthy action of the skin and gives off an unpleasant smell. It may be removed by a hard, dry rub, and it is important to take the rub whenever a bath is out of the question.

What the Skin Does. The skin does four most important things for us.

1. It covers the body as a wrapping without a break in it. Thus it keeps multitudes of microbes from entering. When a patch of skin is entirely destroyed by being scalded or burned, there is such power of life left along the edges that new skin grows out from it day by day until the chasm is entirely covered — provided it is not too large. If it is too large, doctors step in with their wonderful help from grafted skin. By what they do they may save the person from being badly scarred.

2. By means of its sweat glands it helps regulate the heat of the body and keeps it at uniform temperature throughout life. No device of nature is of more practical service to us.

3. It forms the ground against which nerves act and through which we do our feeling. Most of our impressions of heat and cold, of pain and suffering, reach us through the skin.

4. It helps the lungs and the kidneys in their work of sending waste from the body. Perspiration is waste matter that is being eliminated.

For each of us, however, there is something far more important than hot ovens, burned flesh, and the grafting of the skin. It is not probable that we ourselves shall meet these terrible experiences. For us a practical everyday danger is always at hand.

Taking Cold. We may take cold through our ignorance of the laws that govern the health and vigor of the skin. Let us therefore remember that the skin is constantly covered with a slight moisture called insensible perspiration, and that when there is enough of this moisture to be noticed it is called sensible perspiration. One advantage of perspiration is that it cools the body whenever it is in danger of getting overheated. For the sake of grasping the situation more clearly, bear the following facts in mind:

1. When a man is heated from exercise, capillaries in the exercised part of the body are stretched out with the blood which is forced into them.

2. If a heated man, covered with perspiration, sits in a draft, his blood is cooled, the capillaries of the

skin contract, and the mass of the blood goes to some other place.

3. When this occurs, the linings of nose, throat, lungs, and intestines are apt to be overcrowded by the blood which has been forced into them from the skin, and the most sensitive lining suffers most.

Symptoms of a Cold. Usually the first symptom is that a man feels stuffy in nose, throat, or lungs. The explanation of the feeling is the distended capillaries and the condition of the blood itself. Although red corpuscles continue to deal with oxygen as they have always done, still the white corpuscles are now behaving strangely. They get together, many of them stick to the inside walls all along the length of the capillaries, and the more inactive they are, the less do they seize and destroy intruding microbes. These microbes, therefore, remain uncaptured in the blood and continue such mischief as their nature makes possible.

When a man has a cold, the trouble often is that influenza microbes have escaped the white corpuscles and have firmly established themselves in the part of the body which is congested with blood.

In view of these facts it is not hard to understand why a man who has a cold is so much more liable to take other diseases to which he is exposed. He is in a weakened condition, and already microbes instead of white corpuscles have the upper hand in his body.

But suppose a cold is coming on, what does our knowledge of the laws of the skin direct us to do about it?

To Check a Cold. Draw blood away from the region of the cold as promptly as possible. Do it in several ways: take vigorous exercise until every sweat gland is active; take a hot bath; soak the feet in hot water; drink hot lemonade; go to bed; sleep warm; perspire freely. By keeping warm in bed, the blood goes to the surface of the body, and delicate internal membranes are relieved of superfluous blood. White corpuscles are also stirred up, and restoration begins. Stay in bed until the feeling of cold is over. One night may suffice. When you leave the bed, wipe off with warm water, then take a quick wash with cool water. This will stimulate the nerves of your skin without chilling the blood itself, and will keep you from taking cold afterwards.

To Prevent a Cold. Here are three rules of prevention that you should remember:

1. Never sit in a room that feels chilly. A long slow chilling of the body does even more harm than a draft.

2. Never come in heated from hard exercise and cool off in a chilly room. Multitudes of colds are taken in this way. Either continue to exercise in the room, or wrap up thoroughly. Best of all, take a quick, cool bath in a warm room and change your damp underwear before you sit down.

3. Remember that there is little danger of harm to health, however damp the clothing may be, so long as vigorous exercise is kept up.

4. Obey all the general laws of eating, exercise, etc., and follow the instructions on page 207 about educating the body to adjust itself.

The reason for all this is that bodies are provided with the extraordinary power of regulating their own temperature by means of fuel and work.

Internal Temperature. Let a man live in central Africa or let him travel to the coldest land; let him stay in the burning heat of his city home or wander in the cool shadows of the country; let him be in bed or in the harvest field, in the countinghouse or in the mine; wherever he is, he will find that, if he is well, a thermometer placed under his tongue always indicates about ninety-eight degrees of heat. This is what we call normal temperature.

In each place, also, even if he is not well, the heat of his body will change but little. We say that a man has a slight fever if his temperature is 100° F. If it reaches 102°, we grow somewhat troubled; if it rises to 103° and then to 104°, we are truly anxious; for no man is expected to live after his temperature has reached a higher point than 107°.

It is well for us that the body has this power to keep the blood warm independent of outside conditions; for if it were otherwise, — if we were as cold-blooded as is the frog, — we should be as useless in cold weather and in cold places as he is. We should have to hibernate in winter as he does.

Warm-blooded Animals. Birds, as well as all animals that begin life by taking milk from their parents — mammals they are called — are warm-blooded. Each has for itself this wonderful power of meeting the changes of the weather with a constant temperature of its own. As a result, such animals are generally warmer than the surrounding air and are called warm-blooded for this reason.

Cold-blooded creatures usually feel cold to the hand when we, who are warm-blooded, touch them. Their bodies have no power to stay warm when the air is cold about them.

Although we have this power, it is nevertheless true that even the heat of our warm bodies can fail. Men do freeze to death. They cannot be frozen almost solid and then thaw out again and live, as certain frogs have been known to do. People may live in the coldest countries and be active and healthy there, but the one condition is that they help the body do its work by preventing the escape of more heat than the same body can promptly replace. Never confuse these two facts:

1. During health the inside heat of the body changes little from year's end to year's end. If it changes many degrees up or down, we die.

2. The skin feels warm or cold as the air about it changes. Skin and nose and toes may freeze, but the inside temperature remains practically unchanged.

Why Clothes are Needed. Put a dozen people in a small room, and the room grows warmer because those human beings give off enough heat to warm the air about them. In a cold country or in a cold room each body must keep within itself as much of its own heat as it can. Naturally, therefore, we wear more clothes at one time than at another. We are treasuring up our own supply of heat for our own use, and we know that we lose this heat largely from the surface of the body — from the skin. We therefore wrap up. Do not forget that we are warmed not by the cold we keep out but by the heat we keep in.[1] Flannel succeeds better than cotton in preventing the escape of heat, because more air is entangled in the mesh of woolen goods than in a cotton fabric. This air keeps the heat from passing from the body, because air is what is known as a poor conductor of heat. For this reason we choose woolen goods for winter wear and cotton materials for summer.

[1] If the body is not sufficiently covered, heat radiates from it and escapes. Cool air takes its place at once and surrounds the body as a layer. Capillaries in the skin now contract and force the blood away from the surface to the inward parts of the body. These parts then become congested, while the skin feels cold, because the contracted blood vessels can only hold a small supply of blood. By putting on extra clothing and by rubbing the body hard, we cause blood vessels in the skin to expand, more blood passes through them, and we are warm again.

Moreover, each additional layer of clothing means an extra jacket of air underneath it. And since air is a poor conductor of heat, several layers of thin garments — with their separate layers of air between them — are often a warmer protection than one thicker garment with its one layer of air underneath.

In summer we choose the thinnest clothing and the fewest possible layers of it. We wish to make it easy for heat to escape. Nor is clothing our only warming device.

Warmth through Exercise. Why do boys say, "It's so cold we've got to run to keep warm"? For this reason — when muscles contract and when blood moves fast, the heat of the body is decidedly increased. Vigorous exercise of large muscles increases the heat of the blood. Then, as this blood reaches the skin, it is cooled by the evaporation of the perspiration. Our body has two ways by means of which it controls heat escape:

1. By regulating the flow of blood into the skin.
2. By the sweat glands and what they do.

Food as Fuel. Consider that while you exercise you breathe hard and expel warm air from your lungs. This comes from heat produced by your body while it works. And what is the source of its power both to work and to produce heat? Watch yourself at the dinner table after exercising. You have such an appetite as comes only when you have been using up your supplies. Food is to the body what fuel is to a stove, and in a certain way your machine has been burning up its fuel while you worked and grew warm. Your appetite is nature's call for a fresh supply of food.

Sometimes active exercise leads the body to call for so much fuel that the stored-up supply — fat — is rapidly reduced. Any football player will tell you that during the football season he loses fat which he gained during the previous summer.

To Reduce Fat. The body has need of extra fuel when it does unusual work, and it then draws on its reserved supply. A fat man applies this power of the body to his own case. He studies himself both in the mirror and on the scales and concludes that his body has stored up too much fuel in the shape of fat. He knows that to get rid of it he must use it, and at once he begins a course of vigorous exercise which gives hard work to large muscles. They respond by calling for fuel, and if he is faithful day after day, the mirror and the scales will soon show that he is accomplishing his purpose — that he is losing his fat.

Perhaps we wonder how it happens that although we sometimes exercise so hard as to use up much of our fuel, the thermometer shows a gain of so little bodily heat. As we already know, the reason rests partly with the sweat glands. They are such a successful cooling device that whenever we exercise enough to raise our temperature above its normal point, they promptly manufacture their clear-colored liquid. And when once manufactured, they send so much of it out upon the skin to evaporate there that, no matter how warm we feel, the internal temperature of the body is kept from rising too high for safety.

The body is thus seen to produce its own heat, while it also cools itself when we overheat it. Through this power, however, we may take cold unless we know how to prevent heat from escaping too fast when the body needs it.

Educating the Body to Adjust Itself. We may so train the body that it will increase its power to adjust itself to different states of heat and cold. In other words, the body can be educated. This may be done by following the rules about eating and exercise already given and by attending to a few other points.

1. Do not spend much time in overheated rooms, that is, in places heated above 70° F. The body grows exceedingly sensitive to cold if it is kept constantly too warm.

2. Do not overweight yourself with clothing in a warm house or take vigorous exercise in heavy garments. In other words, regulate your clothes to your need.

3. If you are in good health, take a quick cold bath every morning. Nothing is better for preparing the blood vessels for changes in temperature.

Don't run about with bare feet and get chilled before this early bath. The body should be warm for it. *Never give a cold body a cold bath. Never take a cold bath in a cold room.* Let the room be as warm as 70°. It may be even warmer. Let the cold bath be short — one minute is long enough. You are using the water for a tonic, not for a scrub. Use two rough towels, one wet and one dry. Wet face and neck first, then arms, chest, abdomen, back, legs, and feet. If you have no bathtub or shower bath, take a washbowl of water, and wash and wipe one part of the body after the other quickly in the order given. (The shower bath also goes from the neck downwards.) Waste no time. Rub fast and hard until the skin is pink. The body will glow with a feeling of warmth and vigor. If it does not glow,—if it is cold instead, — then you are not quite vigorous enough to take the cold bath. You must get stronger first.

4. Keep the body clean by taking a soap-and-water bath at least once a week.

He who attends to the various rules connected with bathing, eating, exercise, and the heating of the body will find at last that he has reached the happy condition where sudden changes in temperature and unexpected drafts do not harm him as they did in former days.

We see, then, that the real purpose of hygiene is to help the body as it tries to help itself. In reality, food, muscles, blood vessels, and sweat glands work together for the regulation of body temperature. At the same time the central regulator of all their activity is the nervous system. To this we now turn our attention.

QUESTIONS

1. What were scientists trying to learn about the heat of the body in 1775? 2. Describe the way they tested the human body in heated rooms. 3. How hot was the air? 4. What happened to beefsteak, eggs, water, and watch chains that were in the same room? 5. How did the men feel? 6. What saved them from being cooked? 7. When are the sweat glands most active? 8. How many sweat glands is a human being supposed to have? 9. Describe the epidermis. 10. Describe the dermis and tell what is in it. 11. Describe perspiration. 12. What things are mixed with perspiration on an unwashed skin? 13. What four things does the skin do for us? 14. From what part does new skin grow to cover a wound? 15. When is skin-grafting necessary?

16. What is insensible perspiration? 17. What is sensible perspiration? 18. What is the purpose of perspiration? 19. When a man is heated, what happens to the capillaries? 20. If he sits in a draft, what then? 21. What is generally the first symptom of a cold? 22. Describe the behavior of the white blood corpuscles at such times. 23. Why is a man who has a cold more liable to take other diseases? 24. If you feel a cold coming on, what should you do to check it? 25. Give three rules for preventing colds. 26. What can you say about the heat of the body in different countries? 27. What is our normal temperature? 28. Describe warm-blooded and cold-blooded creatures. 29. What can you say about the inside heat of the body? 30. Why does a room grow warmer when people are in it? 31. Why should we wear more clothes at one time than at another? 32. From what part of the body do we lose heat? 33. Why is flannel warmer than cotton clothing? Why are

several layers useful? **34.** Are we warmed by the cold we keep out or by the heat we keep in?

35. How does exercise keep us warm? **36.** In what two ways does the body control the escape of heat? **37.** What connection is there between food and the power of the body to heat itself by exercise? **38.** When much exercise is taken, what stored-up fuel is drawn upon? **39.** What may a fat person do to change his appearance? **40.** How can you explain the fact that hard exercise has little effect on the inside temperature of the body? **41.** Since the body can cool itself when it is too warm, what is the danger in being overheated? **42.** Give four rules for helping the body to adjust itself to heat and cold. **43.** What is the real purpose of hygiene?

CHAPTER XV

THE NERVOUS SYSTEM

The Value of Sensations. If a cat felt no unpleasant sensation when he needed food, he would never bestir himself from a comfortable nap for the sake of eating. If a mouse felt no unpleasant sensation when the claws of a hungry cat were hooked into his skin to seize him, he might allow himself to be caught and eaten without a struggle. If human beings felt no discomfort in the coldest weather, they might carelessly let themselves be frozen to death.

The Hedge of Nerve Warnings. So it is on every side. All along the way we go, our sensations are our best protectors. Indeed, during each day of our lives our animal kindred and we ourselves travel through life over a road that is guarded on either side by what might seem to be a hedge of nerve warnings called sensations. The sensations themselves are of various kinds, hunger and thirst, cold and heat, headache, toothache, stomach ache — ills of many different sorts. But through each separate one we learn at last that by giving heed to our sensations — to those that are disagreeable as well as to those that are agreeable — we do much to preserve our health and to make the pathway of life safe and delightful.

ONE SET OF FIBERS AT WORK

What Nerves are. Before the microscope was invented even the very wisest men had to do much of their scientific work by guessing. They imagined that each nerve was a tube filled with something exceedingly fine and delicate called animal spirits. But in recent times, guessing has been discarded. For the microscope shows that nerves are not tubes at all. Instead they are a system of fine fibers which carry stimuli and messages back and forth between the other parts of the body and the brain. These fibers look like slender threads. They run from the brain to the spinal cord, from the cord to the muscles, then from the muscles up

ANOTHER SET OF FIBERS AT WORK

again to the spinal cord and the brain. Just under the skin these fibers cover the body in a close network, and it is through their aid that living beings feel, and move, and control their actions.

Work of the Fibers. More than this, it is well to know that nerve fibers are divided into two groups which do two kinds of work. One group carries stimuli to the brain from skin, eye, ear, nose, tongue, and from all the internal organs of the body. These are called sensory nerves. The other group carries commands from the brain to every point in the body that needs directing. These are the motor nerves.

When a baby sees a flame, laughs with joy, thrusts his fingers into it, and pulls them out again with a scream, several sets of fibers have been at work.

1. One set, from the eyes, helped the brain to see a lovely color.

2. Another set brought word from the brain to the muscles of the hand, "Feel it."

3. A third set carried a stimulus to the brain, which seemed to say, "Something dreadful is happening to the fingers."

4. A fourth set brought the prompt command, "Pull the fingers out of the color as fast as possible."

Different Sets of Fibers. In the meantime other groups of fibers set other muscles to work, so that at one point the baby opened its mouth to laugh with joy and a moment later opened it again to scream with pain. Still other fibers commanded the heart to pump faster and send more blood to the excited head. They commanded the tear glands to manufacture salt water with incredible speed and in great abundance. They set lungs and vocal cords to work, too. And as the result of so much stimulation sent up to the brain and so many commands sent down from the brain, we end with a nervously exhausted, screaming, red-faced, tear-stained baby, rather a dejected-looking piece of living machinery.

Stimuli. If we could ever follow any series of messages up and down, we should learn to understand how swift their flight is. Stimuli from remote regions of the body fly upward to the brain, and there, in what is really the great central station, the various kinds are recognized and attended to. Commands are issued at once, and each of these now goes by its own road downward to the spinal cord. From there it is flashed across an unbroken long-extended fiber to a toe, or a finger tip, or to any muscle of the body that is to be controlled by it.

The longest fibers are those which carry an impulse from the toe up into the spinal cord and those which bring commands back over the same distance. In a tall man these fibers, carrying messages in one direction or the other, may be four or five feet long. And their work is as perfect as that of any short fiber.

Distribution of Nerves. If by any clever process we could separate the nerves of a man from the rest of his body, if we could turn each one of these nerves into something stiff and firm, and then could stand the entire group on a pedestal in precisely the shape which it had when it did its work in the body, we should understand better than we do the marvel of its structure. This network of stiff nerves would be so delicate and so closely woven together that we should be able to follow perfectly the outline of the man to whom it belonged. We should know his height, the breadth of his shoulders, the size of head, hands, and feet; while at the same time we should note that on certain parts of his skin the network was specially fine and delicate.

Nerves that show the Outline of the Human Body

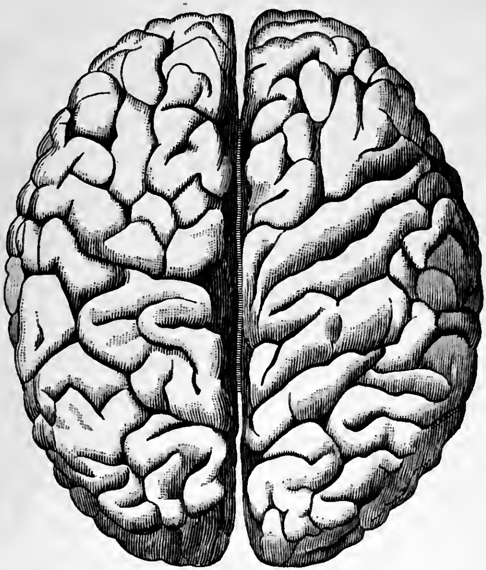
If, going further, we should cut that nerve figure open, we should find other great clusters of nerves that showed the outline of every separate organ of the body.

Having seen all this, unless we know the facts of the case, we might give a thousand wild guesses as to what this wilderness of nerves was for and how it was ever able to control the sensations and the movements of a human being. Some knowledge of the working of the brain will help explain the difficulty to us.

Memory and the Cerebrum. Dr. W. H. Howell, in his physiology, describes the case of a dog who met with misfortune, lost the upper part of his brain, — the cerebrum, as it is called, — and led a singular life ever afterwards.

Those who were studying the case kept the dog alive a year and a half, and they saw that although the animal did not suffer actual pain, still he did not know enough to feed himself; he did not even recognize his food when he saw it; he showed no pleasure when caressed nor any fear when threatened. Not a trick that he had ever learned did he now remember. And as for burying bones for future use, there was no thought of such a thing. Indeed, from the moment he lost his cerebrum, until he died, he seemed to do no thinking whatever. Memory was so entirely gone that he recalled nothing that he had ever learned. Formerly he had been a clever and sprightly dog, remembering old tricks, learning new ones, stealing bones and burying them, frightening cats, loving his friends, and fighting his foes; but from the moment he lost his cerebrum all was changed. Henceforward he was dull, inactive, and uninteresting.

In man the cerebrum is even more important. He may lose part of it through disease or accident and still be able to live and think, but if he loses the whole of it, he dies. If it is injured he suffers in various ways. It is the region of the brain that is most vitally connected with our thinking, with our activity, and with our power to judge what is best for ourselves.



THE HEMISPHERES OF MAN'S CEREBRUM, THE CENTER OF CONTROL

This constantly active and most important part of the nervous system lies just under the skull. It is the largest division of the brain, and is separated into two halves called hemispheres, as shown above.

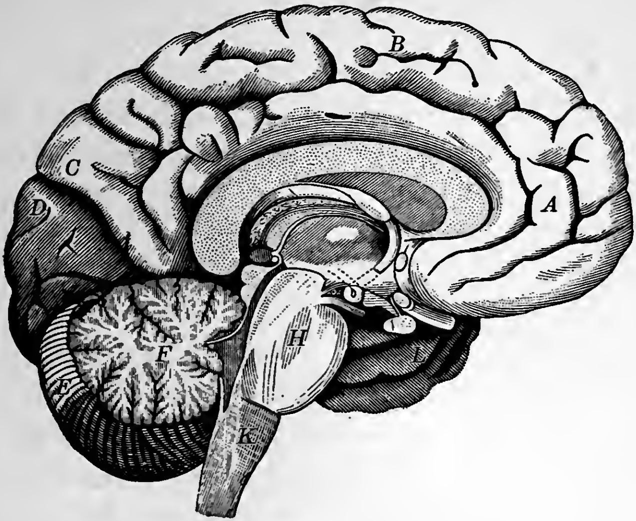
Structure of the Brain. If you ever have a chance, take in your hands a human brain that has been preserved in alcohol and let a doctor describe it to you. First of all, however, you will notice that the substance itself looks like nothing so much as a neatly folded, closely packed mass of gray putty, so lifeless and so uninteresting that you may feel like exclaiming: "Is this the great commander in chief of the body of man! Is this queer-looking stuff the basis of all my thinking and my feeling!"

But let the doctor hold it and explain it to you part by part. Watch his eyes; listen to his voice as he does it; for they will tell you that to him this lifeless mass is interesting in every smallest division. He will press one part away from another at the surface, and you will see that although each can be separated slightly from its neighbor, still all are firmly held together at the center.

He will show you the cerebrum and another division, called the cerebellum, and will probably mention them in that order, for the cerebrum is larger and higher up — a soft gray cap, it seems to be, folded closely in deep creases, overlapping everything below it. Nevertheless, the cerebellum is in sight just beneath, at the back of the head. It too is folded and wrinkled and gray.

Cerebrum, Cerebellum, and their Convolutions. It may be that you will ask some questions about these deep creases in both cerebrum and cerebellum, — convolutions, they are called, — and it may be that the doctor will answer very thoughtfully, "The more wrinkles, the more wits," for that states the case concisely. "But what good do the convolutions do?" you ask again.

"Give more surface for the gray stuff to be spread over," comes back the answer, quick and positive. And this answer leads the doctor up to the point of his greatest enthusiasm, the gray substance of the brain.



A CUT THROUGH THE BRAIN

A, B, C, D, L show folds in the cerebrum; *E, F* show the gray and white of the cerebellum; *K, H* show the upper divisions of the spinal cord

The Gray and the White Brain Stuff. Gray substance is all you have seen thus far, for it bends in and out with every fold and crease as if the whole substance of the brain were solid gray. "But look here," exclaims the doctor, as he presses open a deep cut which he has made with his knife through the gray cap, "see how little gray there really is — only an outside layer about an eighth of an inch thick and thinner than that in spots. But every thought you have, every pain you feel, every plan you make, every hope that thrills you, every purpose and ambition of your life, is intimately connected with this thin gray layer that covers the white substance below it."

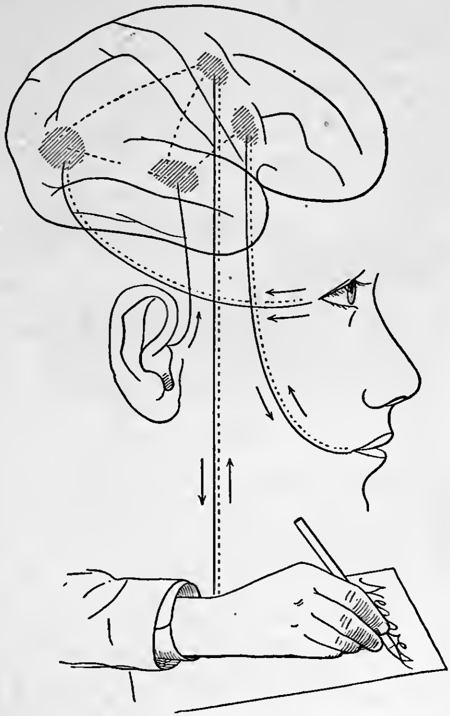
While you are thinking this over in amazement he will probably go on to say that the injury or disease of any part of that gray layer of the brain may rob you of one sense or another, or even destroy your brain power in the very direction where you thought you were strongest.

Centers in the Cerebrum. "If this particular brain had been injured here," the doctor will say, pointing to a certain spot on the gray surface, "its owner would not have been able to recognize anything that the eye looked at. And this is the worst sort of blindness, for when the sight center of the cerebrum is gone a man cannot so much as remember what seeing was like."

Accidents to the brain have taught some of these facts; diseases of the brain have taught others; while the study of the brains of animals has let in a flood of light on the whole subject. So that at the present time scientists know that a definite part of the gray layer is active for each separate sensation and for the power to move each separate part of the body.

How the Skull protects the Cortex. This layer is called the cortex, and *cortex* means "bark." It is clear then that the gray bark that covers both cerebrum and cerebellum is the most precious part of the human body. For this reason it needs a stout protection, and it gets it in the firmly knit, sturdy skull which surrounds it.

Instead of being a snug fit in its case, the brain is separated from the skull by a little space filled with liquid. And it is this well-housed brain that controls the nerve machinery of the body.

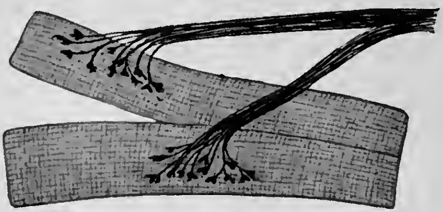


Roads To and From the Cortex

Sight, hearing, and touch have special centers, but taste and smell are near together

Nerve Machinery. From what seems to be a confused tangle of fibers under the skin, we might imagine that messages would sometimes get lost on their journey—that those intended for one particular spot might find themselves delivered at the wrong place, bringing despair to the brain. But this never happens. The confusion is only apparent; it is caused by the way the bundles of fibers are variously bound together.

If we had eyes keen enough to see the fibers themselves, instruments delicate enough to do the work, and hands steady enough to use the instruments without tearing the fibers, we might unwrap them, bundle after bundle, and trace them from start to finish. We should then find that every white nerve is a bundle of nerve fibers, each one of which is neatly and snugly wrapped by a fatty covering that makes it look white. We should also find that the difference between large nerves and small nerves is quite the same as the difference between large bundles and small bundles of telephone wires, for in each the number of separate strands explains the size.



NERVE FIBERS THAT END IN MUSCLE

Spinal Nerves. As we studied the nerves in this way, we should discover for ourselves where the largest ones are and how they are related to the backbone. We should see that the bones of the back are so ingeniously locked together that a round opening is left on each side of each pair of vertebræ, and that as there are thirty-one vertebræ there must be sixty-two openings in all. We should then notice that the largest nerves of the entire nervous system are these sixty-two spinal nerves which find their way to the body through the backbone, and we should see that as soon as each leaves the bone the dividing begins. Large bundles, from the cord, become smaller by dividing, then still smaller. They hold anywhere from two hundred to twelve hundred separate fibers, and as they continue to divide and subdivide they branch in different directions until fibers which started in the same bundle are widely separated.

Often these fibers pass out of the wrappings of one bundle into the wrappings of another. They do this so constantly that the various bundles, as they grow smaller, are joined together in an intricate network. They twine and intertwine, but not a fiber loses its way. Each tiny one of the millions that form the lacework of fibers is a continuous path from some definite point on the skin, or from some muscle or gland, to some definite point in the spinal cord; and as long as no accident or wound cuts the nerve in two, the stimulus which each may receive will travel swift and true from the point of the body where that fiber is stimulated to the spinal cord, which will send the impulse on to the brain by other fibers.

What Accidents teach us about Nerves. But accidents are frequent, and they teach scientists wonderful facts about those long nerve fibers. One of these facts is that nerves are useful or not, according as they remain unbroken. Think of the baby who burned his fingers. His nerves of feeling and nerves of motion were in good running order; he felt pain and could pull his hand away; but if a certain set of fibers had been cut across so that the connection was broken, no stimulus would have reached his brain. The baby could then have left his fingers in the fire until they were burned off, without feeling the slightest pain. If, on the other hand, a different set of fibers had been cut, no command could have reached the fingers from the brain. The baby would have suffered frightful pain, but he would not have been able to move his fingers back or forth to get out of trouble. His arm muscles would have had to come to the rescue of finger muscles and pull the hand away.

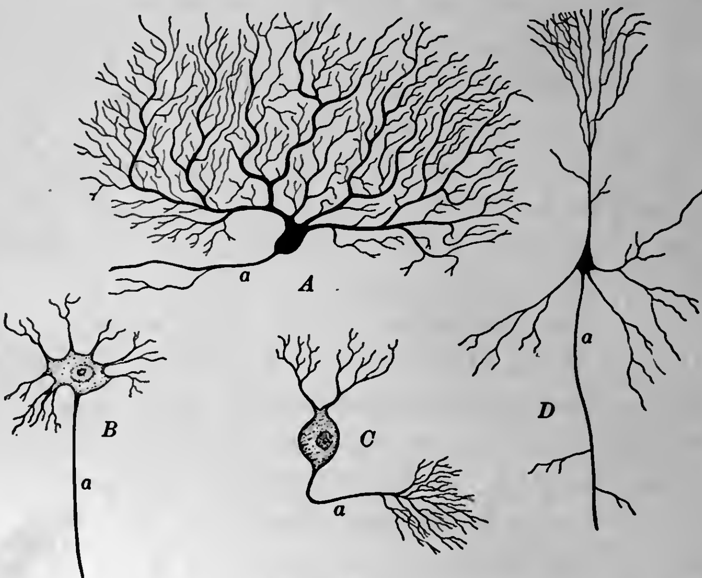
If both sets of fibers had been cut, the baby would not have felt any pain, nor would he have been able to move his fingers. But the burning would have gone on just the same.

Truthful and Untruthful Messages. The impulse which passes over a fiber is always truthful if that fiber is uncut and uninjured from end to end; but if damage has been done, strange reports may reach the brain. Old soldiers testify to this. One of these men lives near my home, and when we met the other day he said, "Is n't it strange, my leg was cut off over ten years ago, but last night the heel of that foot itched and pained me so that I thought I should go crazy?" "What did you do?" I asked. "Put a hot-water bag against the stump, warmed the thing up, and finally got relief." Of course he knew as well as I did that something was irritating the live ends of the fibers that used to send reports from the heel to the brain, and that when the brain received the stimulus it had no way of knowing that the fibers had been cut in two and that their extreme ends were no lower down than the knee. The thinking and seeing part of my friend's brain did certainly tell him the truth. He knew that there was no heel there. Nevertheless, even that knowledge could not change the reports which faithful fibers were bound to send to headquarters in the brain. Something was out of order in their neighborhood, and they clamored for help until it came in the shape of a hot-water bag.

Structure of the Neuron. From all this it is evident that nerves, brain, and muscles are pretty closely connected. Indeed, a microscope in the hands of a scientist reveals strange secrets about this connection and about the structure of nerve substance. I shall state a few of these hidden truths in a straightforward, matter-of-fact way:

1. Just as muscles are made up of muscle fibers, each one of which is a muscle cell, so too is nerve substance made up of nerve cells.

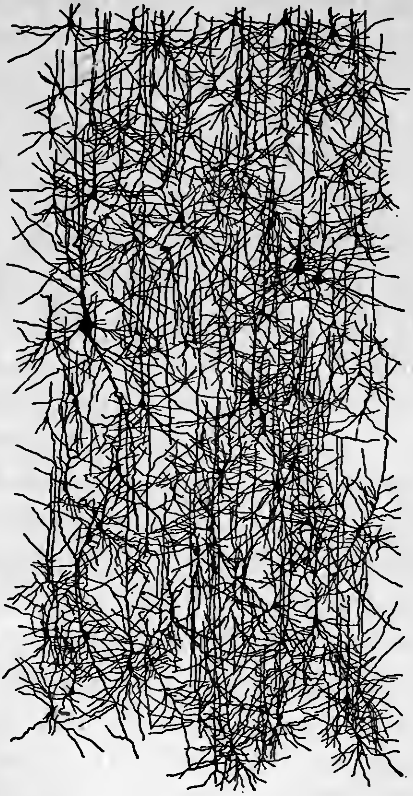
2. A nerve cell is called a neuron. It is made up of four parts: cell body, nucleus of the cell, — its most essential part, — axon, dendrites. A nerve cell has but one axon. It stretches off to a greater



FOUR NEURONS

A and *C*, from the cerebellum; *B*, from the spinal cord; *D*, from the cerebrum; *a*, the axon. The cells *A* and *D* are stained so that the main body and the dendrites are black; *B* and *C* show the nucleus

distance than the other fibers. It is straighter and has branches of its own that extend from it at right angles. When a cell body has several projecting fibers it is easy to pick out the axon, because the other fibers — the dendrites — are shorter and branch out in crooked and forked fashion. The cell body part of the neuron is gray, but the fibers that stretch away from it look white because they have a white covering.



WHERE THE STIMULUS GOES. INTERTWINED NEURONS IN THE CORTEX

Notice the countless crooked dendrites and the many straight axons which run up and down (highly magnified)

(After Kölliker)

3. Each separate fiber in any bundle of nerve fibers is the long axon arm of some neuron.

4. The cell bodies of the nervous system are located in the cortex of the brain, in the center of the spinal cord, and in the ganglia.

5. A ganglion is a group of nerve cells unprotected by any bony covering. There are important ganglia in different parts of the body (see Chapter XVII).

6. Nerve fibers carry stimuli to the spinal cord. There other fibers from other cell bodies receive the stimulus and hasten it on to cell bodies in the cortex of the brain. These cell bodies then send down commands and messages by other sets of connected fibers which stretch away to this part of the body or that.

Nerve Telegraph Stations. Wherever cell bodies are clustered, whether in brain, spinal cord, or ganglion, there we have that interesting place, a nerve telegraph station. It resembles a city telegraph station in two ways:

1. It has fibers that do the work of wires and connect it with different points here and there. These carry messages hither and thither.

2. If a fiber is separated from its own particular cell in that central cluster, it is as useless as is a telegraph wire after it has been separated from its telegraph station.

We see, then, that the vital part of each nerve cell is the gray cell body, and we realize why it is that a cluster of hundreds and thousands of these cells becomes one of the most fascinating centers of activity in the world. Especially so, when it appears that each fiber that enters the central station is responsible for one sort of message alone, and that, so far as we know, it can never carry a message of any other kind.

Since the two sets of fibers carrying messages in opposite directions are so close together, the ignorant person might ask whether or not any mistakes are ever made in the work they do. The answer is, that this never happens. Never in a single instance does any fiber in any bundle carry a message the wrong way or exchange its message for that which a neighbor fiber is carrying. The reason is that each fiber is separated from all the others by its own particular outside wrapping.

What the Gray and White Substances are. And now we understand the gray and white substances of the brain. The gray is a mass of millions of cell bodies packed together and joined to each other by white-covered fibers.

The white stuff is a compact mass of fibers, each one of which stretches away in its silvery sheath from its individual cell in the gray layer. Millions of these fibers join one part of the brain to another part of the same brain. Still other millions go downward towards the spinal cord, and there, within the firm protection of the backbone, stimuli of every sort speed upward to the brain, while at the same instant, on other fibers, countless commands go from the brain to the muscles of the body. It was by studying these commands and stimuli that men learned at last what special work is always done in special regions of the brain. By the same study, also, they learned what fatigue does to nerve cells.

Fatigue and its Remedy. Several years ago Dr. C. F. Hodge studied the brain of the English sparrow and learned some astonishing facts about fatigue and rest. He made two examinations every day; one in the morning, to see how the cells looked after a long night of rest, the other in the evening, to see how they looked after the day's work was done. His great discovery was that always the innermost center of each cell — the nucleus — was plump and round and full in the morning before work began, and that it was much smaller, much more jagged and irregular, after the day's work was over. From his experiments Dr. Hodge decided that, for all of us who own brain cells, it is the cell body and not the fiber of each neuron that gets tired. The case for one and all can be stated in two sentences.

A Sparrow whose Brain Cells are growing Weary with Work

1. Before exertion the nucleus is large and round, smooth and regular.

2. After prolonged exertion the nucleus is small, jagged, and irregular. It has lost substance and become crumpled.

Dr. Hodge also learned that when tired cells have a chance to rest, the nucleus grows larger, rounder, and more regular again. From these and other experiments we learn that when we are tired in body or brain we cannot expect satisfactory work from our nerve cells, and that we should not overtax them when already tired. This does not mean that vigorous exercise does us harm. On the contrary, it is absolutely necessary to us. The one point to remember is that we must always balance exercise by rest. The man, woman, or child who gets up tired in the morning is losing the balance between work and rest. He is getting too little sleep to offset his fatigue. If he wishes to do good work, he must rise in the morning with the feeling of being rested. By this feeling he will know that his nerve cells are in prime condition, ready to serve him well.

QUESTIONS

1. Mention ways in which sensations help us. 2. What does the microscope show about the nerves? 3. Describe the work of different sets of fibers when a baby sees a flame and puts his finger into it. 4. What does the brain do when the stimuli reach it? 5. Which are the longest fibers? 6. Describe the distribution of the nerves. 7. Where do we find great clusters of nerves?

8. Describe the dog that had lost the use of the cerebrum. 9. What of man when he loses his cerebrum? 10. What mental activities are connected with the cerebrum? 11. Where is the cerebrum located? 12. Describe the appearance of a brain preserved in alcohol. 13. Where are the parts held together? 14. Give the names of two important divisions of the brain. 15. Name the larger and describe it. 16. Where is the cerebellum? 17. What can you say about brain convolutions? about the thickness of the gray layer? about its use? 18. What about injury to

special parts of it? **19.** Describe the centers in the cerebrum. **20.** What is the cortex? **21.** Tell how important it is, and how it is protected. **22.** What separates the brain from the skull?

23. What is the difference between large nerves and small nerves? **24.** Where are the largest nerves found? **25.** Describe the backbone and the nerves that pass through it. **26.** How many fibers may be in each nerve? **27.** How do fibers pass from one bundle to another? **28.** Is there danger of their losing their way? **29.** What points do fibers connect? **30.** When do fibers become useless? **31.** What would have happened to the baby who burned its fingers if certain sets of nerve fiber had been cut across? **32.** Let six pupils give six facts about the neuron. **33.** In what two ways is a cluster of cell bodies — a ganglion — like a telegraph station? **34.** What is the essential part of a nerve cell? **35.** How often do fibers make mistakes? **36.** How often do they exchange messages? **37.** What is the gray layer of the brain? the white part of the brain? **38.** Describe a tired nerve cell. **39.** What is the point to remember about fatigue and rest?

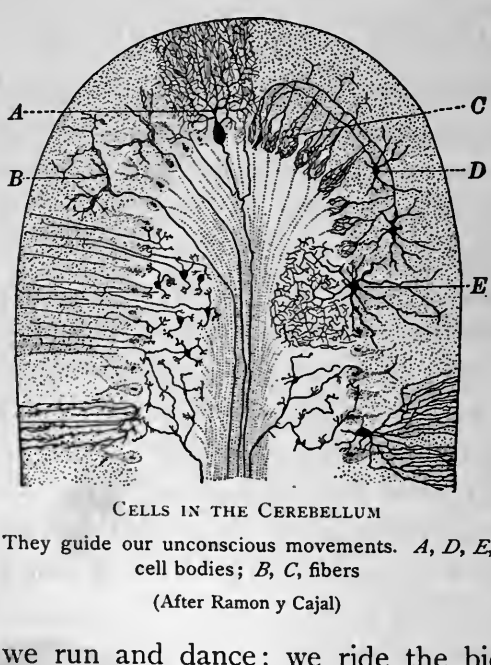
CHAPTER XVI

TRAINING THE CEREBELLUM AND THE SENSES

The Work of the Cerebellum. A French scientist named Flourens once noticed that although a pigeon with a useless cerebellum does not seem to suffer, it does, nevertheless, have the greatest difficulty in standing and in moving about. He saw that when it moves, the muscles do not pull together in orderly fashion, but rather in an independent, helter-skelter way,—each muscle, as it were, pulling for itself without reference to any other muscle, so that instead of walking, the poor bird turns one somersault after another in rapid succession.

Dr. Flourens also noticed that the less the cerebellum is injured, the less the pigeon is troubled with these disorderly movements, although even then it walks in a staggering, drunken way.

From these and other facts which they have gathered, men who study the subject conclude that the cerebellum is an enormous help to the cerebrum in the matter of controlling such muscles as are guided by our will power. They say that while the cerebrum is the commanding general of the nervous system, the cerebellum is the chief of staff, the one that helps take charge of numberless movements which we have learned to make through persistent, diligent practice. When we were babies and were learning to walk, we thought about each step as we took it. If our minds were diverted, if certain special neurons stopped attending to our footsteps, we tumbled down instantly. For weeks, and even months, we hardly dared to walk alone.



Cells in the Cerebellum

They guide our unconscious movements. *A, D, E,* cell bodies; *B, C,* fibers

(After Ramon y Cajal)

To-day, however, after years of practice, we walk anywhere without giving a thought to any separate footstep. We even step so fast that we run and dance; we ride the bicycle, and we swim. Indeed we do all this so well, and we are able to think of so many other things while we use our feet and hands, that it looks very much as if they had become quite independent of the brain. This, in fact, explains the whole situation. Their movements have at last been put in charge of a different set of nerve cells. The happy part of this arrangement is that the particular neurons which do what we might call this underground managing for us are, as a rule, more trustworthy than those which help our conscious thinking and moving.

Training the Neurons. The same law and the same power of the neurons hold good in other directions also. What trained baseball player stops to think of each separate run and slide, how to hold the bat, how to pitch the curved ball, how to catch it? He simply takes his place to play the game; he trusts his trained neurons to help him, and he finds that almost unconsciously he makes the right motion at the right instant, that he plays the game even better than he could tell another how to play it.

This is quite as true in still other kinds of action. I know a freshman in college who has lately taken up a noticeable practice. Often when he stands still, and even while he walks, he may be seen suddenly to straighten his neck and press the back of it firmly against the inside of his collar. Why does he do it? Simply because he believes that his head bends too far forward to be creditable, and he has made up his mind to put his neck muscles in charge of a new set of neurons. Whenever he thinks about it, therefore, he sends imperative orders to those muscles. They straighten his neck promptly, and he gets his head up where it belongs. He knows that each pull in the right direction helps, and that if he persists long enough he will finally get his neurons so well trained that they will end by making the muscles hold his head up all the time without any conscious thought about it on his own part, and that this will relieve his mind for other affairs.

Results of Training the Neurons. When we are teaching ourselves new lessons, the time for encouragement is at the first sign that we are doing the desired thing unconsciously. For example, we may be training various sets of nerve cells to help us do certain things in definite ways, — to walk like a soldier, to sit erect, to talk in a low voice, to hold knife and fork and spoon as we should, to recite the multiplication table, or to repeat a poem, — and day after day we may be discouraged by the fact that as soon as our own thought is off the subject we fail in our struggle; but, without warning, some day the moment for encouragement will come. We shall find that we have done the desired thing as we wished to do it, even while we were not thinking about it, and by that sign we shall know that we have reached the turning point. By being persistent a little longer, those particular neurons will have their lesson by heart, the fight will be won.

This method of training is admirable for any neurons which we wish to press into service, but, even when we are not training them on purpose, they often get trained in spite of our real desire. As an example, think of those which control the muscles of the face. When you are glad or sad some day, try to catch the expression of your face in the mirror, or look at the face of some one else who is happy, or angry, or suffering great pain. In every such case you will find that, unconsciously, the muscles tell a plain, straightforward story.

Neurons and Facial Expression. The truth of course is that almost every feeling we have may express itself in the face, and that each repetition of the expression is one more lesson for the nerve cells that control those muscles to learn. The sad man, the worried man, the happy man, the hopeful or the discouraged man — each has his own telltale face muscles, and a good student of human nature learns to read these faces almost as easily as if they were the pages of a book spread out before him. It is evident, then, that every young face is shaping itself to the expression it will have later, and that the time is sure to come when the tale of our inner lives will be told by the outward expression of face and manner. When this time arrives we may long to hide the facts about the history of our emotions. But we shall find that we cannot cheat the neurons. Instead, the story which they have been trained to tell will proclaim the facts about us whenever and wherever we show ourselves.

Four Great Truths about Neurons. Thus far in this chapter we have laid bare four great facts:

1. He who wishes to learn to do any sort of muscular work easily and well, and to make sure that what he has learned cannot be forgotten, must by diligent practice put the performance of that special work in charge of its own set of unconscious neurons.

2. Neurons are often so quick and clever that they learn that which we would much rather they would not learn, and they proclaim the truth even when we wish them to hide it.

3. If we wish our neurons to declare that we are courageous, kind, and sincere, the only way to make them do it is by being courageous, kind, and sincere.

4. He who pretends to have desirable qualities when he really lacks them will find that through the power of his neurons, in spite of his desire, he actually declares to those whom he meets that it is all mere pretense.

In addition to all else, our special-sense neurons need training. They are located in the cortex, and they control seeing, hearing, touch, taste, and smell.

Training the Senses. A friend of mine whose senses are all in good working order is developing two of them in a delightful way. He thinks he is simply studying birds. This indeed he does, but while he studies birds his eyesight grows keener in its power to recognize them, while his hearing also grows more trustworthy; and the outcome of it is that almost never does a bird fly overhead within sight or sound of him but he recognizes it at once.

Sometimes he knows it by the way it flies; sometimes by the color of wing, breast, or tail; sometimes by its shape; sometimes by its size; sometimes by its song. Whatever the mark, in a flash, when he sees the bird or hears it, he knows it and names it. Others who are with him may have seen nothing but a bit of color passing by or a small shape on a swaying tree top; but he has seen and heard all that the trained eye and ear can see and hear, and he is able to give to the color, the shape, or the sound its own definite bird name.

Whether a man watches birds or collects stamps, coins, or pictures, — whether he is blacksmith, preacher, carpenter, lawyer, merchant, editor, sailor, or newsboy, — he will find that trained senses lead to the promised land of success.

Men in all countries have discovered this for themselves. We are told[1] that natives in central Australia know every bird track and every beast track by sight, and that this knowledge does not come to them

[1] Related by Baldwin Spencer and F. C. Gillen.

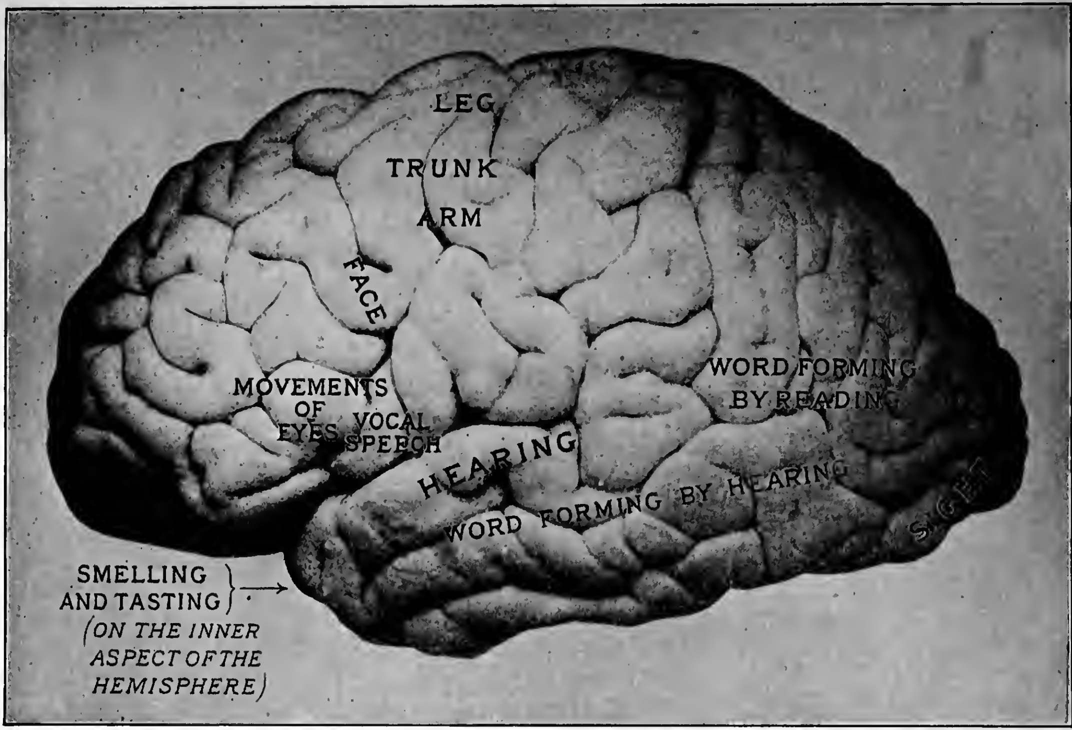
through any accident. It seems, indeed, that from earliest childhood Australian boys and girls are taught to notice tracks of all sorts, and that at the same time they are also taught to imitate these tracks with their fingers in the sand.

The result is that a full-grown, experienced tracker, as he is called, can follow obscure tracks which we should never notice and can recognize them even as he rides past rather swiftly on the back of a horse.

But eyesight and touch do not stand alone; the power to smell may be trained, too. Think of the Indians in Peru. Dr. Carpenter says that in the darkest night these people can tell, by the smell which reaches them, whether a stranger who approaches is an Indian, a European, or a negro. For them, as for the others, it is a trained sense that does the work.

We see, then, that the same law is true for all sorts of people, in lands however far apart. Everywhere, he who wishes the keenest and the surest sense of sight or sound, taste or smell or touch, may secure it by *close attention and constant practice.* In other words, by attention and diligent practice we may form right habits for our senses and develop the power which we desire.

The encouragement is that by being persistent enough in the direction of the senses — or in any other direction — we compel the nervous system to help us form habits that will stand by us for life.



THE LEFT HALF OF THE HUMAN CEREBRUM

The words "leg," "trunk," "arm," "face," are printed over the centers that control the corresponding parts of the body. Other words show where different sensations and memories are located

Machinery of the Senses. Along with all these facts it is important to remember that each separate sense depends on the work done by three parts of a delicate piece of machinery.

1. Apparatus in which nerve endings receive the stimulus — eye, ear, nose, skin, etc.
2. Fibers which carry the stimulus.
3. Cell bodies in the cortex — the gray covering of the brain — which recognize the stimulus.

The Brain the Center of the Senses. In the case of each sense, also, we must suppose that the outside apparatus itself knows no more about what is happening to it than the mouthpiece of a telephone knows what we say when we speak into it. In point of fact the receiving apparatus of each sense is nothing more than a marvelous device for receiving its own special kind of stimulus. Eye, ear, skin, nose, tongue — each is a piece of apparatus fitted with nerve-endings that receive stimuli of a certain kind and send them to the brain on a distinct set of fibers. The cell bodies in the brain feel our sensations for us.

Since we know that exercise develops any part of the body, and since we have learned that our senses may be developed by habits of attention and by constant practice, we are not surprised to hear that by examining a brain after death a trained scientist can tell just which set of nerve cells did the most work during life.

Enlargement of Sense Centers. These men may, for example, take a bird that has lost its life and point to a certain place on the cortex. "You see it is very much enlarged," they say. "That is the part that always had the most exercise. It is the sight center of the brain." And at once we call to mind the stories we have heard about carrier pigeons—about the keenness of their vision and the distance they fly to reach home again.

The brain of a dog may be examined next. "There!" the scientist exclaims, "do you see this part? It is the center for smell, and it is always greatly enlarged in dogs." And now we recall all our dog stories. We remember that a bloodhound will trace a man through a crowded city, that the scent of a dog is one of his most remarkable points.

The examination might go on from animal to animal, each brain showing that one of the senses was more highly developed than the others.

The Sense Centers of Laura Bridgman. Human brains are better balanced, unless something has gone wrong. This was true of Laura Bridgman. She was deaf and dumb and blind and had no sense of smell. Her one connection with the world was through her sense of touch. As a result, the cell bodies of touch received constant daily exercise, while the nerve cells of all the other senses received no exercise whatever. Then came the startling discovery; for after Laura Bridgman died her brain itself told the story of her senses. Doctors examined the cortex and found that it was thinnest at the centers of seeing, hearing, tasting, and smelling. More than this, as might have been expected, the doctors also found that the touch region of Laura's brain was wonderfully developed. In view of all this we draw the following conclusions for immediate use:

1. Although the apparatus itself does nothing but receive stimuli of one sort or another, still, if it is ruined by disease, accident, or careless use, no amount of striving on our part will restore it to us.

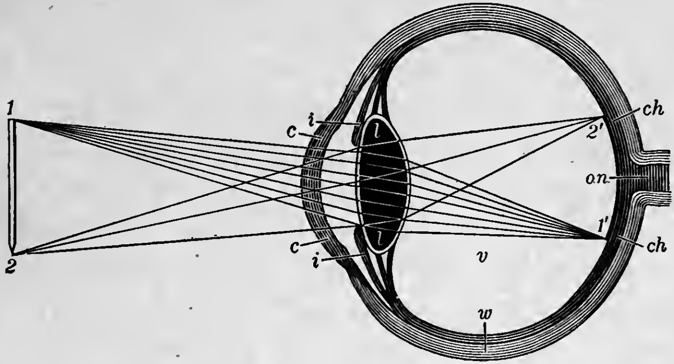
2. If the apparatus of one sense has been wrecked, the other senses may be so highly developed as to help make up the loss.

3. Persistent exercise of any sense will increase the thickness of the part of the cortex to which it belongs.

Although no examination of the cortex of our own cerebrum is possible while we are alive, still we may have the comfort of knowing that we are improving its quality here or there in proportion as we are giving one sense or another more or less exercise. The truth is that our senses are our best friends or our worst enemies in just such measure as we train or neglect them.

By the foregoing facts we have learned that five special senses are the avenues that lead up to the mind. The following additional facts are valuable.

Structure of the Eye. Here we have a socket of bone lined with a cushion of fat. Within this socket is the eyeball. To protect it are eyelid, eyelashes, and the eyebrow. Six small muscles move the eyeball about. One end of each is fastened to the eyeball, the other end to the inside of the socket itself. The lachrymal



THE WAY THE IMAGE OF AN OBJECT REACHES THE RETINA

1, 2, the object; 1′, 2′, image of the same; *c*, cornea; *i*, iris; *l*, lens; *v*, vitreous humor; *w*, sclerotic; *ch*, choroid; *o.n.*, optic nerve

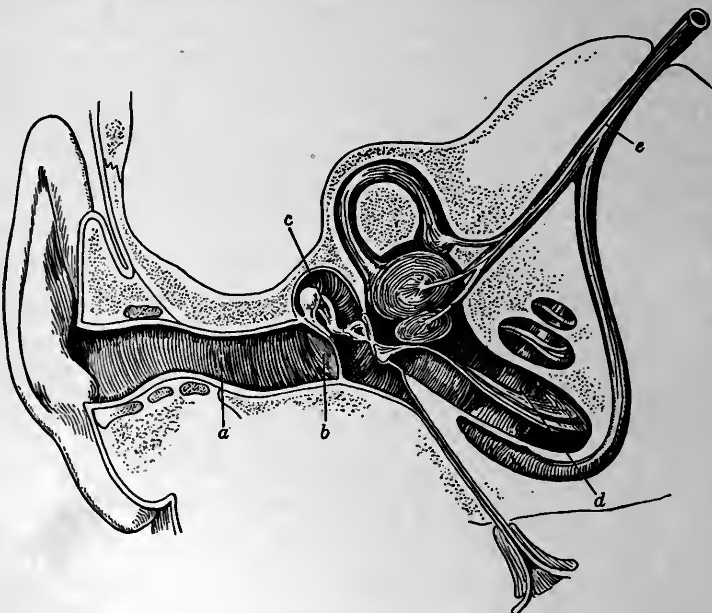
gland, within the socket, manufactures moisture constantly. This moistens the eyeball, then runs off through two small canals, one from the inside corner of each eyelid. From these canals tears run into the nasal duct and then into the nose. If the lachrymal glands manufacture moisture very fast, the eyes overflow, tears stream down the cheeks, and we say the person is crying. We mean that the duct cannot carry the liquid off fast enough.

The eyeball is made up of three layers: the sclerotic coat outside, the choroid coat, and the retina inside. The sclerotic coat is really the white of the eye. In front it is joined to the cornea. This is transparent, like a window, and through it light goes into the eye. Back of the cornea lies the iris, a circular curtain of muscle, lined with coloring matter and pierced by a round opening called the pupil, through which light enters. The size of this opening is controlled by muscles which make it smaller in bright light and larger in dim light. This iris curtain is the colored part of the eye. What is the color of your iris? The crystalline lens is back of the iris. It focuses the light on the retina. It also divides the inside of the eyeball into two compartments. The small one in front, just behind the cornea and divided in two by the iris, is filled with a watery substance, the aqueous humor, that runs out if the eyeball is cut into. The large compartment back of the lens is filled by a transparent jellylike substance inclosed in a membrane and called the vitreous humor. Behind all this is the lining of the back of the eye — the retina.

The optic nerve enters the eye from the cerebrum and spreads itself out on the retina. Light rays enter through the pupil in the cornea, pass through the crystalline lens, strike on the retina, and make an image there. By the help of the optic nerve the seeing center of the brain receives the picture in a flash. The whole structure is a marvelous camera, more delicate than any man-made device. We need to treat it with the greatest care. The following directions are important:

Treatment of Eyes; Headache, Eyestrain, etc. In strong light, lower the eyelids. Sit erect while reading. Have a good light on any close eye work — reading, embroidery, drawing, and the like. Light should shine upon the work from the left. It should not shine into the eyes. Avoid twilight reading. Do most of your eye work by daylight, not by artificial light. Eyes are strained by light that flickers or is dim. Any strain damages the eyesight. Hold your book about eighteen inches from the eyes. If you cannot do this without eyestrain, if you have frequent headache and no auto-intoxication, your eyes should be examined. You may be nearsighted, and have to hold your work too near to the eyes. You may be farsighted or even slightly cross-eyed. You may have what is known as astigmatism. In any case of strain, see the oculist. He will give you glasses that will correct the trouble. Spectacles are always better than eyeglasses, because they are steadier on the nose. They strain the eyes less. Whether you wear glasses or not, in any close eye work look up frequently to rest the eyes. Remember that you have but one pair to serve you through life, and that the better you treat them the longer they will last. Use your eyes very carefully after measles, scarlet fever, chicken pox, diphtheria, and any disease that weakens the system. Never wipe the eyes on a public towel. Disease microbes may be on it. Keep your own fingers from your eyes for the same reason.

Structure of the Ear. The outer ear includes all we see of it, and also the auditory canal into which sound



A CUT THROUGH THE RIGHT EAR

a, the tube; *b*, the eardrum; *c*, the ear bones; *d*, the snail shell; *e*, the nerve of hearing

waves go. At the inside end of this canal is the membrane called the eardrum. It is stretched across the canal, and sound waves that strike against it make it vibrate. A blow on the ear often breaks it. On the sides of the canal are small glands which secrete wax, a protection to the drum. The middle ear is just beyond the drum. In it are three tiny bones, called hammer, anvil, and stirrup. Ligaments of the smallest size hold the bones together in a chain and fasten them to the underside of the drum. When sound waves reach the drum it vibrates. The small bones are slightly moved by this vibration and pass it on to the cochlea at the entrance of the inner ear. This cochlea is an intricate structure shaped like a shell. Within the inner ear are bony spaces and tubes, called the bony labyrinth. Inside the bony labyrinth is the membranous labyrinth. And here it is that we find the ends of the fibers of the nerve of hearing — the auditory nerve.

These nerve endings receive vibrations of sound. The vibrations travel to the brain on the auditory nerve. It is in the brain that we do our hearing. The entire ear with its three parts — outer, middle, and inner — is merely a combination that forms the road by which sound waves must travel to reach the special hearing center of the brain. The eustachian tube is a narrow connecting passage between the middle ear and the pharynx.

Hygiene of the Ear. Three things must be done for the health of the ear:

1. Keep the auditory canal clean, that wax may not accumulate in it.

2. Don't catch cold. This often inflames the eustachian tube and other membranes, giving intense earaches.

3. Never box the ear. The sudden crowding of air against the eardrum may split it.

The Sense of Smell. Smell stimuli are received by olfactory cells spread out on the sensitive lining of the nose. Nerve fibers go from these cells up to the brain, and there it is, in one definite locality, that we do our smelling. The olfactory nerve is simply the road thither.

The Sense of Taste. Nerve endings on the tongue are called "buds of taste." Each is joined to the brain by many nerve fibers, and these transmit taste stimuli to the brain. It is in the taste center of the brain that we do our tasting.

The Sense of Touch. By means of this fifth sense, endless information reaches the brain from the surface of the body. The nerve endings themselves are in the skin. Longer and shorter nerve fibers carry touch messages to the brain, and there we do our feeling.

QUESTIONS

1. Describe Flourens' work with pigeons. 2. How does the cerebellum relieve the cerebrum? 3. Describe learning to walk. 4. Mention other activities that end by being done unconsciously. 5. Describe training the neurons. 6. What are the results? 7. What causes a

person's facial expression? 8. Describe some case in which nerve cells are trained in spite of our real desire. 9. Give the four great laws of nerve cells. 10. In studying birds, what special senses are trained? 11. How do native Australians train their eyesight? 12. In training the senses, what is the secret of success? 13. What three parts are there to the machinery of each separate sense? 14. Where is the center of the senses? 15. What can you say about the enlargement of sense centers? 16. Which sense is most developed in a bird? in a dog? 17. Tell about Laura Bridgman, and about her brain after death. 18. What three lessons do we learn from studying the senses? 19. How many special senses have we?

20. Describe the location of the eyeball; its protections; the muscles that move it. 21. What does crying show about lachrymal glands? 22. Name the layers of the eyeball. 23. Why is the cornea like a window? 24. Where and what is the iris? the pupil? 25. What makes the pupil grow larger or smaller? 26. Where is the crystalline lens? 27. What does it do? 28. What is the aqueous humor? the vitreous humor? 29. Where does the optic nerve spread out? 30. Mention different parts of the eye through which light passes to get to the retina. 31. Where is the picture formed which we see? 32. Where do we really do our seeing?

33. What is the outer ear? 34. Where is the eardrum? 35. What makes it vibrate? 36. Where does earwax come from? 37. Describe the middle ear and its bones. 38. How do sound waves reach the cochlea? 39. Describe the cochlea; the bony labyrinth; the membranous labyrinth. 40. What is the auditory nerve? 41. Where do we do our hearing? 42. What is the one thing that the entire ear is made for?

43. Name the nerve by means of which we do our smelling. 44. Where do we really smell, in the nose or in the brain? 45. Where are the "buds of taste"? 46. What joins them to the brain? 47. Where do we do our tasting? 48. Where are the endings of the nerves of touch? 49. Where is it that we do our feeling of every kind?

CHAPTER XVII

HAPPINESS, HEALTH, AND THE SYMPATHETIC GANGLIA

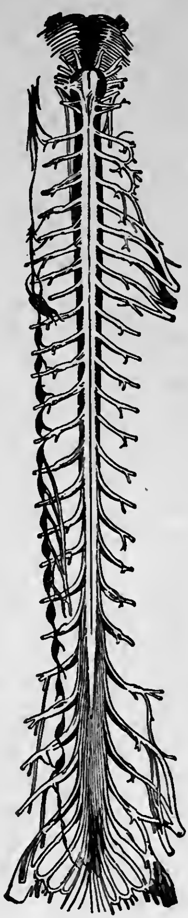
Vital Activities Independent of our Will. Before studying this chapter, test yourself in two ways: First, try with all your might to make your heart stop beating. Try to prevent the great arteries from expanding and contracting as the blood surges through them in pulses. See whether, by thinking and willing hard enough, you can prevent your sweat glands and oil glands from manufacturing salt water and oil. Will your stomach obey you when you command it to stop digesting your food?

Now turn the tables. Say to your heart as it pounds steadily along: "Beat faster. Beat faster. You must beat faster." Will it obey you? No; it goes neither faster nor slower by the fraction of a second. Your brain and your heart seem to be as independent of each other as if they belonged to different bodies and lived in different worlds.

Nevertheless, as we all know, life itself depends on the beating of the heart. We know that whenever it stops and fails to start again we shall die, but from year's end to year's end we think nothing about it. At night we lie down to sleep with no anxiety lest the steady pulsing may cease. By day we run, dance, dive, swim, play leapfrog and football, walk on our hands and turn somersaults, knowing all the while that the heart is affected by every move we make; but at the same time we seem to know that somehow the body has an arrangement for controlling its most important machinery whether we pay attention to it or not.

Vital Activities Controlled by the Ganglia. Up and down on each side of the backbone is a chain of ganglia which is more important to life, perhaps, than any other part of the nervous system. It seems to be nature's device for relieving the brain; a device for keeping the vital machinery running by day and by night without our needing to think about it.

This system of nerves is the means by which the heart, stomach, and other organs which are independent of our conscious control are able to do their faithful work whatever commands we give them. It is called the sympathetic nervous system.



SPINAL CORD WITH SPINAL NERVES

On the left are a few sympathetic ganglia joined by their rope of nerve fibers

Structure of the Sympathetic Nervous System. So far as location and arrangement are concerned, it is not very difficult to understand the facts about this system, and the following outline will give them as simply as possible:

1. Forty-nine ganglia unite to form the main part of the sympathetic nervous system. These ganglia belong together as a complete set. Twenty-four lie on one side of the backbone, twenty-four on the other side, and one lies in front of the lowest vertebra.

2. Each of the forty-nine ganglia is connected with its neighbor above and its neighbor below by what might be called a rope of fibers.

3. This string of ganglia, held together by its peculiar fiber rope, seems to hang like a loop, with the backbone as a pole in its center.

4. The cell bodies in the different ganglia send fibers off to definite parts of the body — to heart, stomach, liver, and elsewhere. At these different places the fibers are so closely woven together that they form a network called a plexus; small ganglia are interlaced with each plexus.

5. One very important plexus is near the heart; another is near the stomach.

A Nerve Plexus. On the street the other day my six-year-old friend suddenly bent his head forward and thumped it into the stomach of an elderly man who came that way. The boy was surprised when the old man bent himself double and almost groaned aloud, for the child himself knew nothing about the plexus near the stomach, neither did he know that wherever fibers are thickest, there it hurts most to be punched. The boy's brother, fourteen years old, understood the situation perfectly. "Because," as he said, "you see it hurts awfully to be thumped in your stomach like that."

But all this has to do with the outside of the stomach. Now recall Dr. Cannon's experiments with cats. Think of the close connection which he discovered between the state of the mind and the work the stomach is willing to do, and do not forget that it is through nerves alone that the mind can ever affect the stomach in this way or that.

Good Temper and Digestion. A friend of mine says that many a time when he was young he himself had the cat's experience. He was quick-tempered, nervous, and excitable, and he found that if he lost his temper while he was eating, or if he even became unpleasantly excited, he immediately felt as if all the food in his stomach had turned itself into a weight of lead that could not be dislodged.

Sometimes his stomach even went so far in its rebellion as to force up everything he had swallowed.

Experiences of this sort taught the boy one of the great lessons of his life — that he must keep calm and serene at mealtime. Later he learned that, in thousands of cases, bad digestion comes from a bad disposition, and not a bad disposition from bad digestion, as so many imagine.

Why Happiness Helps the Body. From these and other observations and experiments scientists find four good reasons why happiness helps not only the stomach but all other parts of the body too.

1. A happy state of mind affects the ganglia in such a way that they compel the small blood vessels to expand. This allows fresh blood to flow easily through them.

2. A happy state of mind affects the nerves that control the lungs. They inhale more air. This means that they get more oxygen; and this, in turn, means that the blood is more completely purified in the lungs.

3. A happy state of mind affects the ganglia that control the heart, making it beat faster; this forces fresh blood rapidly through the expanded blood vessels. And rapidly moving blood gives rich nourishment to nerve cell and muscle, making it possible for them to do good, energetic work.

4. A happy state of mind affects the ganglia of the stomach so promptly that its churning is better

done; while, at the same time, more gastric juice pours in to help digestion along.

A cheerful schoolroom, lively games, pleasant friends, becoming clothes, comfortable travel by land and by water — anything that makes us happy without doing us harm is a help to the body through the sympathetic ganglia.

We now see why it is that we learn our lessons faster, recite them better, and are quicker-witted in every direction when we are happy than when we are unhappy. It is simply because in the former state every organ in the body is doing its best work, and because the brain gets the benefit of it all through an improved blood supply. The serious fact is that the human machine is so delicately balanced that when even the smallest part of it fails, the whole may hitch and halt. Wear out the fire box or the boiler of an engine, and no matter how perfect the rest of the machine may be, it will run no better than a worn-out affair that is rusted in every joint.

It matters not where the hitch in the human machine begins — whether with too much food, too little mastication, too little exercise, too much worry, excitement, anger, fear, or torment of any mental sort; for wherever the start may be, the feelings are sure to be pulled into the reckoning erelong, and after that the trouble is increased tenfold.

Service from the Ganglia. It is evident, then, that we have within our own reach methods for securing good service from our sympathetic ganglia.

1. To avoid as if it were a poison each thought and emotion that saps the vigor of the ganglia — hatred, malice, envy, jealousy, anger, despair, discouragement, anxiety, worry, fear.

2. To help the ganglia through love, joy, hope, courage, faith, trust, belief in others, belief in ourselves, good cheer.

3. To obey all the laws of health that we know anything about.

It was in studying this last point that Professor Kraepelin and others came to their conclusions about the effect of alcohol on nerve tissue and efficiency, as described in the next chapter.

QUESTIONS

1. What control have you over the beating of your heart? over your pulsing arteries? 2. If you should command the stomach to stop digesting its food contents, what result would there be? 3. What part of the nervous system has charge of internal bodily activities? 4. How many ganglia are there in the sympathetic nervous system? 5. Where do they lie? 6. How are these ganglia connected with each other? 7. Where do the cell bodies of the ganglia send their fibers? 8. When fibers are very closely woven together in a network, what do they form? 9. When a man is punched in the stomach, which plexus of nerves suffers? 10. How can the mind influence the stomach?

11. What was Dr. Cannon's discovery about the state of a cat's feelings and the work of a cat's stomach? **12.** What similar discovery did a man make about his own state of mind and his digestion? **13.** What effect does a happy state of mind have on the blood vessels? on the lungs? on the heart? on the stomach? **14.** What can you say about anything that makes us happy without doing us harm? **15.** Why is it that we do better work both with the mind and with the body when we are happy than when we are unhappy? **16.** For the sake of the sympathetic ganglia, which emotions should we shun? **17.** Which emotions will help these ganglia?

CHAPTER XVIII

ALCOHOL AND EFFICIENCY

Tests made with Students. Several years ago Professor Kraepelin of the University of Heidelberg, in Germany, did some experimenting in connection with the students of the place. He was just the one to carry on the experiments, because he had already made a special study of the nervous system, and because in all parts of the world scientific men recognize the authority of his name. He himself says that he really wished to save a little of the reputation of wine and beer, for he saw that science was crowding pretty hard against every drink containing alcohol.

In experimenting with his students Professor Kraepelin always gave small doses. He knew, as we do, that those who use alcohol frequently in large doses ruin their lives hopelessly. Proofs of this are on every side in every land. There are, however, thousands of honest people who heartily believe that alcohol taken in small doses is a help on all sorts of occasions. It was in this direction, therefore, that Professor Kraepelin experimented.

Various university students were eager to know facts, willing to be tested, and quite ready to drink or not to drink, according as the progress of the investigation required. One test had to do with a man's quickness in adding up columns of figures for half an hour a day during six days. Those being tested without alcohol added their figures as rapidly and correctly as they could. Then the alcohol period began, and for thirteen days the same students used alcohol and continued to spend the half hour a day at their addition tables. The work went more and more slowly, until the nineteenth day. Alcohol was then dropped. The men continued to add, and there was immediate and marked improvement in the work they did. This continued until the twenty-sixth day, when they returned to alcohol, and once again there was a change for the worse.

Thus the seesaw between alcohol and no alcohol went on until no doubt remained. It was clear to all that the men always did poorer work during the alcohol period and better work when they had no alcohol.

Tests made with Typesetters. There was also the test with the typesetters in Heidelberg. Dr. Aschaffenburg carried on this set of experiments. Four skilled men were chosen. Three were in the habit of using alcohol in small amounts, the fourth acknowledged that he took too much once in a while, but all were ready to go without it or to take it, as the tests demanded. Indeed all four men were anxious to know whether they could do swifter and better work with the alcohol or without it.

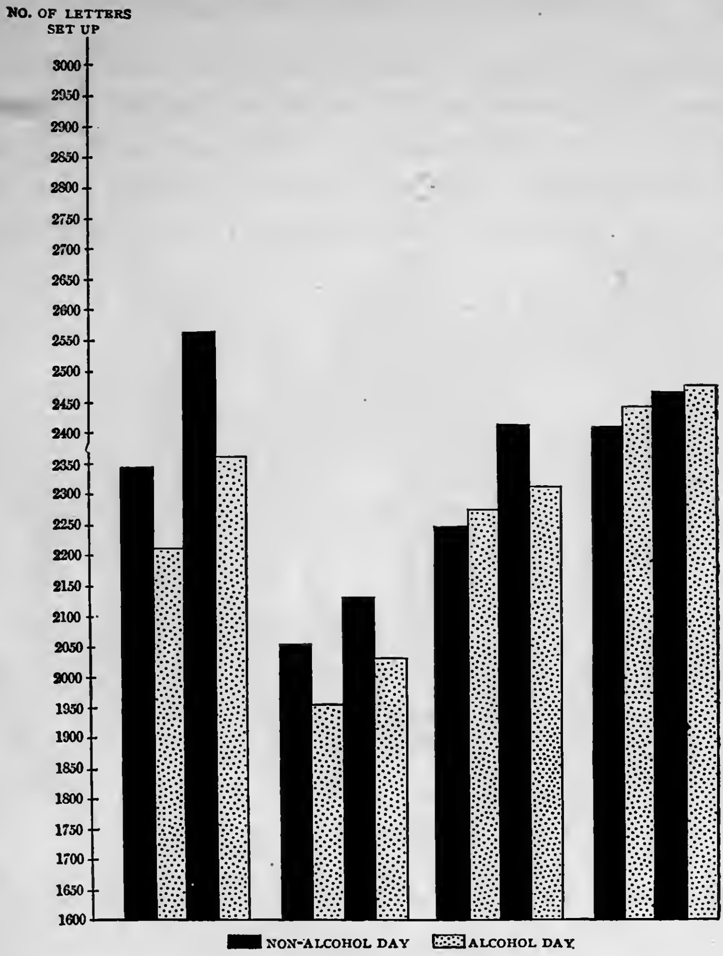
The amount which Dr. Aschaffenburg gave them on the days when they took alcohol was one ounce and a quarter; that is, the wine which they drank had about two and a half tablespoonfuls of alcohol in it.

The men drank it fifteen minutes before they began their typesetting. For fifteen minutes each day they worked at full speed. Each did what he could to set up as much type as possible; and yet, as shown in the illustration on the next page, in every case but one alcohol hindered and did not help him.

But—and here we meet a curious fact—in every case the men themselves thought they were doing better and swifter work when they used alcohol than when they did not use it. Indeed this is the usual belief of all who use alcohol. Still, many careful experiments prove that the opposite is true.

Experiments with Soldiers. Sweden has turned special attention to her soldiers. She wishes to know whether a glass of wine or beer taken before the shooting begins will help or hinder a soldier who tries to hit the enemy.

Lieutenant Rengt Boy carried on the experiments. The soldiers selected were picked men, all fine marksmen. Their targets were two hundreds yards away, and guns and rifles were used. On different days the men, in groups of six, were tested with alcohol and without it. The amount of alcohol given was about three tablespoonfuls. This was taken in the shape of wine or beer,



THE RECORDS OF FOUR MEN

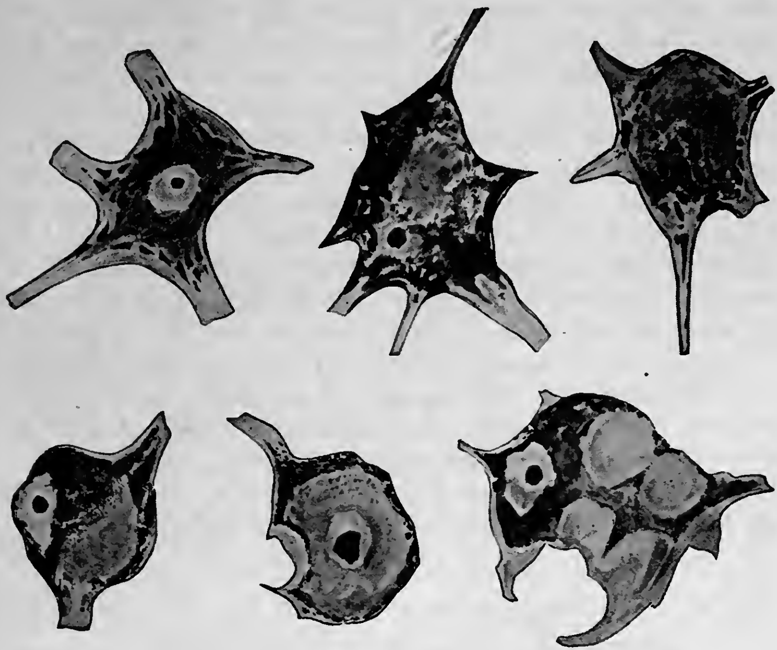
Each group of four columns shows the work of the same man for four successive days. Black columns show how many letters they set up on non-alcohol days. Dotted columns show how many letters they set up on alcohol days sometimes the night before, sometimes within an hour of the target practice. The result of it all was the discovery that in every instance each man in each group did his quickest firing and his best hitting when he had had no alcohol whatever for two or three days

Target Practice for Swedish Soldiers
They need steady nerves

beforehand, and that he did his poorest work when he had used alcohol at any time within twenty-four hours. As staff surgeon Mernetsch reports:

When under alcohol the result was 30 per cent less hits in quick fire; and the men always thought they were shooting faster, whilst actually they shot much more slowly. When slow aiming was allowed the difference even went to 50 per cent.

Alcohol and the Neuron. With these facts in mind we are not surprised to learn that the condition of the neuron of the drinker is often quite enough to explain his



CELLS FROM THE SPINAL CORD

The upper cell at the left is normal, with its nucleus in the center. The upper cell at the right is dead; it has no nucleus whatever. The other cells are swollen and the nucleus is pushed far to one side. These diseased cells were taken from alcoholic persons who died in Claybury Asylum, England. They were drawn by Dr. Mott for Sir Victor Horsley

failures. The illustration tells the whole story. Compare that clean-cut, trim, normal cell, taken from a healthy brain, with the ruined cells from alcoholic brains.

QUESTIONS

1. What tests did Professor Kraepelin of Germany make with students? 2. What do some people believe about the helpful effect of wine and beer? 3. Describe the German tests in adding columns of figures? 4. What did these tests prove about the effect of using alcohol when one wishes to do quick, accurate work? 5. Tell about the alcohol tests made with typesetters. 6. How much alcohol did the men take on the days when it was given? 7. Describe the experiment. 8. What did the men themselves think about the work they did after using alcohol? 9. What did this experiment prove? 10. What did Sweden wish to discover about wine and beer? 11. What kind of men were selected for the experiment? 12. Describe the experiment. 13. How much alcohol was used? 14. What did the staff surgeon say about this experiment?

15. Describe the appearance of normal, healthy brain cells; of cells ruined by alcohol. 16. What sort of work is done by a damaged brain cell? 17. Since we cannot see the neurons in a living brain, how can we tell what their real condition is?

CHAPTER XIX

THE MENACE OF THE MICROBE

The Public Drinking Cup. On the first of September, 1909, the Board of Health of the state of Kansas began to enforce a new law:

The use of the common drinking cup on railroad trains, in railroad stations, in the public and private schools, and in the state educational institutions of the state of Kansas is hereby prohibited, from and after September 1, 1909.

No person or corporation in charge or control of any railroad train or station, or public or private school, or state educational institution shall furnish any drinking cup for public use, and no such person or corporation shall permit on said railroad train, station, or at said public or private school, or state educational institution the common use of the drinking cup.

When this law went into effect, and when thirsty people arrived at the station and found that they must have their own drinking cups, some of them were displeased. They thought the Board of Health was growing altogether too particular. But read the following facts and judge the case for yourself; I quote the account from a report that was printed in February, 1909.

Professor Davidson of Lafayette College asked ten boys to apply the upper lip to pieces of flat, clean glass in the same way as they would touch a cup in drinking. These glass slips were then given a thorough microscopic examination, and they showed an average of about one hundred human cells, or bits of skin, and seventy-five thousand bacteria[1] to each slip. This from one application of the lip.

A cup which had been used in a high school for several months without being washed was lined inside with a brownish deposit. Under the microscope this proved to be composed of particles of mud, thousands of bits of dead skin, and millions of bacteria, among which were scores of germs corresponding in all details to those of tuberculosis. Some of this sediment was injected under the skin of a healthy guinea pig, and in forty hours the animal died. A post-mortem examination revealed the fact that death was due to the presence of a sufficient number of pneumonia germs to cause blood poisoning.

A second guinea pig inoculated with the cup sediment developed tuberculosis. Careful inquiry proved that several pupils in the school from which the cup was taken were then sufferers from this dread disease.

Before going on with this chapter, give attention to the following statements:

What a Microbe Is. The word *microbe* means "small life." A microbe is any living plant or animal which is too small to be seen without a magnifying glass. Many people speak of microbes as germs. This is quite correct, for both words refer to the same tiny bits of plant and animal life. Most microbes are harmless. Some microbes give us disease of one kind or another. These are called disease microbes. Each microbe disease is caused by its own special kind of microbe. These microbes do their mischief after they enter the body. Microbe diseases are called preventable, because if we

[1] Different kinds of microbes.

destroy the microbes, or prevent them from attacking us, we are sure to escape the malady. By keeping the body in vigorous condition we may avoid illness even after certain microbes have attacked us.

How Microbes Attack the Body. Microbes find entrance to the body by one or the other of four different roads.

1. *Through the nose and lungs*, in air laden with dust mixed with microbes, for example. Any man who spits where the saliva may dry and be blown about is bringing danger to the air which other people must breathe. He who sneezes or coughs without a handkerchief held to his face is doing the same thing. He is scattering microbes in the air, and if he has a cold or tuberculosis, the disease microbes are able to give the same cold or consumption to those who breathe the air after him.

2. *Through the mouth*, in food and drink or in anything which may be put into the mouth — the point of a pencil, a half-eaten apple, an unwashed spoon or fork, fingers moistened to turn a page. Even a kiss on the lips may be a serious matter.

3. *Through contact with microbes from the skin* of a person just recovering from such diseases as smallpox, chicken pox, scarlet fever, and measles.

4. *Through the aid of creatures that puncture the skin* and leave disease microbes in the blood. Mosquitoes do this, one kind giving us malaria, another

kind giving us yellow fever. We shall study the subject later. Fleas carry bubonic plague from rats to human beings. The stable fly carries infantile paralysis from person to person. Lice probably carry typhus fever.

Now it is because of such facts as these that we guard ourselves from disease microbes at every possible point. When you next take up a public drinking cup, think of the microbes that may be on it. When drinking at a sanitary fountain the lips touch nothing but water, and no harm can be done either to yourself or to those who may follow you. The individual drinking cup is equally safe.

Protection for the Eyes. But the public drinking cup is not the only danger that threatens school children. Think of pink eye and trachoma, described in *Health and Safety*. They always go by the road of touch. No healthy eyes will take either disease unless they are touched by something which has already touched diseased eyes — for example, fingers, a contaminated towel, or a handkerchief.

My next-door neighbor seems to know this already. He came from school the other day and said, "Pink eye has started in school, but I 'm not going to catch it." "How will you escape?" I asked. "That 's simple enough," he answered; "I 'll keep my hands away from my eyes; I 'll never touch them with anything except my own towel at home. I 'll have to do this, because at school my hands touch what other boys have touched, and I never know what microbes may be on them." I commended my neighbor and was glad to see that he did save himself from pink eye, although his best friends had it. The probability is that they not only touched their eyes with their hands but also used the common towel. This should be banished from every schoolhouse. Even books, used by others, may bring disease microbes to us. If possible, avoid books that have become soiled through long use.

So much, then, for the direct ways by which microbes may travel from person to person; but what about the indirect road?

Why we Object to Flies. Think of our numberless, small, unwelcome neighbors, the flies. Why do intelligent people object to the presence of flies in kitchen, pantry, and dining room? Why do we carry on an endless fight against them? For the simple reason that flies never either wash or wipe their feet. Yet think for a moment where those tiny feet travel. Where dead things lie, where filth is worst, where disease has been, there do we find flies in greatest numbers. And it is always in just such places that they lay their eggs and multiply.

Study the subject for yourself. Look at the open garbage pail in the summer, or at a pile of decaying waste anywhere. Notice the multitudes of flies there, then notice where flies stand thickest in your home. From the barnyard, where they multiply fastest in horse manure, or from a sewage farm with feet covered with typhoid microbes, they may fly to your dining table and leave living microbes on bread, beef, cake, candy — on anything you eat. For in the line of food, flies enjoy not our waste alone but also whatever we have prepared with greatest care as food for ourselves. They stand on this dainty food of ours with their soiled feet, and

THE HOUSE FLY

a, egg; *b*, larva, or maggot; *c*, pupa case, or puparium; *d*, adult male. (All enlarged)

we swallow the food plus the microbes which mark their footsteps. This danger from the fly is very real.

Of every hundred soldiers who died in the Spanish-American War, twenty were killed by bullets, eighty by microbes. And over and over again the doctors blamed the feet of the flies for having put typhoid microbes on the food the soldiers ate.

What Flies Eat. But aside from the microbes they carry on their feet, there is mischief done by flies through the refuse which they are willing to eat. Dr. Lord, a scientist, allowed flies to eat sputum from the lungs of a man who had tuberculosis. Those flies

WHERE FLIES MULTIPLY

then deposited their flyspecks, and fifteen days later Dr. Lord examined the specks and found living tubercle bacilli in them. Those microbes of tuberculosis had been taken into the mouth of the fly, had gone safely through its body, were alive when they left the body as flyspecks, and after fifteen days were as vigorous as ever and ready to threaten the living tissue of human beings. Think of the flyspecks which are left on our food when flies stand upon it.

Safety through Carefulness. Such facts as these explain the widespread fight against the ever-present fly. We have no objection to the little creatures themselves, but we greatly object to the diseases which they may inflict upon us. We therefore do what we can to reduce their numbers.

A careful housewife keeps the garbage pail closely covered, that flies may not enter and lay their eggs there. She has it emptied often and scalded, that such eggs as may have been laid on the food before it went into the pail may be killed and never allowed to hatch. She screens doors and windows and never allows a fly, living or dead, to find lodgment on her food, either in kitchen, in pantry, or on the dining table.

A careful grocer meets this same situation in the same way. If he must display his foodstuffs to charm the passer-by, he puts them under glass or stretches netting about them. He knows that the sight of flies on his foods will drive the careful housewife from his door.

A careful man who keeps horses sees to it that the stables are kept clean. He knows that, whenever possible, flies lay their eggs in such places; that each egg hatches out into a tiny maggot; that maggots soon turn into full-fledged flies, ready to lay eggs for another generation; and that in our fight against the fly the main point is to keep the creatures from multiplying.

A careful city takes the same facts about flies into account. It allows no piles of rubbish to stand about; it allows no dead animals to stay unburied and no stables to remain uncleaned. It insists on having clean streets, and yards with no neglected refuse in which flies may lay their eggs. And it is the desire for health that explains this passion for clean things which now moves all civilized peoples. We wish to breathe clean air in clean streets; we wish to eat clean food in which no disease microbes may be found; we wish to be rid of city waste promptly because we are not willing to run the risk of increasing danger for ourselves from microbes which may be in it and which may threaten us later.

In city and country alike, the intelligence of the citizens decides what their own life and death prospects shall be, for sanitation controls the death rate.

QUESTIONS

1. Give what you can of the Kansas law about the common drinking cup. 2. Describe experiments made with pieces of glass that had touched the lips. 3. Describe the appearance of the cup used in the high school. 4. Tell about the experiments made on a guinea pig. 5. What does the word "microbe" mean? 6. Are most microbes harmful or harmless? 7. Why are certain microbes called disease microbes? 8. Why are microbe diseases called preventable? 9. Why should we keep the body in vigorous condition?

10. By how many roads may microbes enter the body? **11.** Give several ways by which people can bring danger to the air which other people breathe. **12.** Mention ways by which microbes may enter the mouth. **13.** What objection is there to touching the point of a pencil to the tongue? to using unwashed forks and spoons after another person? **14.** Why not turn a page with a finger moistened at the lips? **15.** What diseases are contagious through the skin? **16.** What small creatures give us disease by puncturing the skin and leaving disease microbes in the blood? **17.** Why have people adopted the sanitary drinking fountain? **18.** How does it help? **19.** How may eye trouble be passed from person to person? **20.** How may one avoid taking a contagious eye disease?

21. Why do we object to flies? **22.** Give reasons why garbage, refuse, and decaying waste should never be allowed to accumulate. **23.** Where do flies multiply fastest? **24.** What did the doctors say about the death of soldiers in the Spanish-American War? **25.** Describe Dr. Lord's experiment with flies. **26.** What does a careful housekeeper do about the garbage pail, etc.? **27.** How does the careful grocer guard his foodstuffs? **28.** What does a careful man do about his horses and his stables? **29.** What ought he to know about fly eggs and their history? **30.** What does a careful city do to protect itself from flies?

CHAPTER XX

SANITATION

Country Conditions. If you live in the country, step out of doors and see what the sanitary conditions of your surroundings are. Examine both the inside and the outside of the barn, the stable, the hen yard, the outhouse, and the pigpen. Notice the location of the well. See if it is near enough to other buildings to make it possible for contamination to soak down and across until it reaches your drinking-water. Look for flies and their breeding places. Decide what ought to be done to get rid of them. How about the rubbish heaps and the garbage pail? Do you think everything is properly clean about the place?

City Surroundings. If your home is in the city, go with some grown friend to the most crowded and untidy part. Enter any tenement house and make discoveries for yourself. You will find that city crowding often reaches a perilous point; that even when people object to miserable surroundings, they are sometimes obliged to use dark halls, dark cellars, and wretched bathrooms. The real owners of these houses seem to act as if they thought the darkness would save their tenants from disease as well as from disgrace. Yet in such places everything helps disease along. Gas pipes leak and sewer pipes are out of order; the air grows heavy with carbon dioxide, with illuminating gas, with foul gases from broken sewers, with the smell of unwashed people and unclean clothes. At the same time dampness adds to the danger. Even in our day there are thousands of people who do not know that dampness, darkness, and dirt are just the three conditions that are best for microbes and worst for men.

The Meaning of Sanitation. And it is because all this is so true that nowadays we hear so much about sanitation — the science of securing conditions which favor health. The problem itself faces both the country home and the city tenement. And in studying it we find that always and everywhere we are called upon to guard three things in connection with our homes.

1. *The air we breathe.* Neighbors cannot allow each other to contaminate the air with their disease microbes; neither can they permit the presence of unpleasant odors from decaying garbage or from pigpens, stables, and the like.

2. *The water we drink.* This must be so protected that even if a neighbor in the country has typhoid fever, no waste from his body shall have the slightest chance to reach the drinking-water of the neighborhood.

3. *The food we eat.* This must be fresh and pure, without any sign of adulteration. It must be protected both by state and national laws and by the coöperation of all those who sell foodstuffs to each other.

Cleanliness the Watchword. At the present time cleanliness is indeed the watchword for every community — clean air, clean water, clean food, clean surroundings of every sort. But it sometimes seems as if people in the country had to work harder to gain this cleanliness than those in the city. Note the following contrasts:

1. In the country each home must get rid of its own garbage, parings, fruit skins, table waste, bones, etc. All this must be carried to the pigs, or it must be deeply buried and covered lest it give off an odor as it decays. In the city all such waste goes into a garbage can, and a man from the health department takes it away. We have no further thought about it except to keep the pail scalded and covered.

2. In the country the kitchen may lack a sink, in which case waste water must be carried out and thrown in a sunshiny place, that it may not become a gathering place for flies. The outhouse must be strictly guarded from flies and kept in a sanitary condition by the use of lime. In the city the waste from every sink and bathroom is carried out of town by the sewage system.

3. In the country such dry wastes as ashes, paper, scraps of iron, old shoes, rags, etc. must be disposed of by each owner as best he can. Sometimes part of this rubbish is burned, part buried. In the city all such rubbish is packed into bags, and at stated times these bags are carried off and disposed of by the workers of the city health department.

4. In the country the roads often suffer sad neglect. In the city, men of the street-cleaning department do the work and are paid for it by the taxes of the citizens. In fact, all city work of every department is paid for by these taxes.

5. In the country, as a rule, each separate home is responsible for the kind of water the family must drink, for the well is in a place selected by the owner of the house. In the city, water comes in pipes from out of town, and the Board of Health decides whether or not this supply is safe from typhoid-fever microbes.

From these contrasts it looks as if country folk had a hard time and city folk an easy time with their sanitation problems. But turn to another side of the same subject.

Sunshine and Air in Country and City. Remember that every living creature should be surrounded by sunshine and fresh air every day. Then think of the glorious chance for both in the country, and of the poor chance for either that thousands upon thousands of city people have. Think of the towering tenement houses, where the streets between are like deep narrow valleys, and where children play every day without a ray of sunshine about them. Think of the thousands upon thousands of inside

A Village Home

rooms in every crowded city, where no outside window ever lets in air and sunshine. In 1911 there were 90,000 such rooms in New York City alone. Think of persons ill in such places. Think of the dark corners and the filthy cellars and of the disease microbes safely lodged and living in them. Think of all the babies that are here robbed of every chance of life and of the little children who must surely suffer when an epidemic comes.

In London the crowding is so great that 300,000 of its citizens live in tenements of one room for a family. Forty thousand of these live 5 in a single room, while 8000 live 8 in a room. Other cities are crowded, too.

HOMES IN NEW YORK CITY

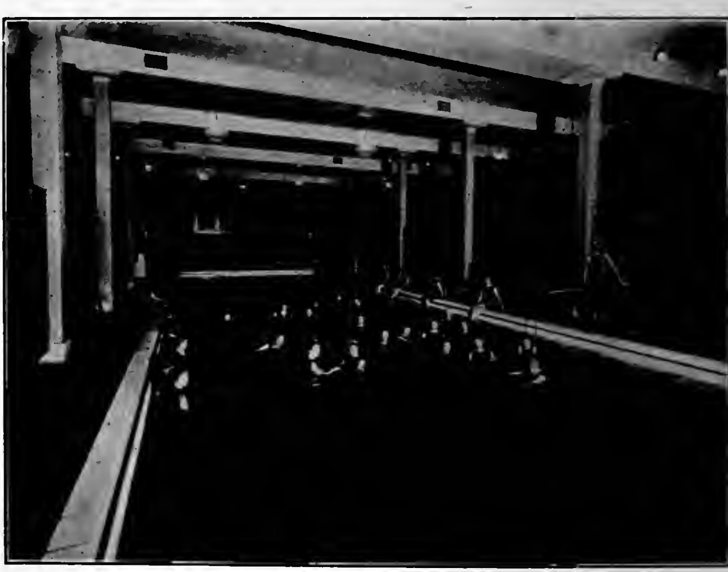
Rear Tenements and the Death Rate. In New York City the darkest and most unwholesome houses are rear tenements. These stand so close behind the front tenements that the distance between them is from two inches to five feet. Of course each building keeps daylight from the other, but at the same time the rear tenement is always the older, the more unclean, and the more neglected of the two. Mr. R. W. DeForest tells us that at one time, in these rear tenements, one baby died for every five that were born. These places were then called "infant slaughter houses," because of the terrible conditions which killed the children.

New Tenement Regulations. But, in course of time, reform came. A new tenement-house department was established, and it made better building regulations. The new requirements, condensed here, are worth keeping in mind as a guide for the building of any home.

No room without a window opening out of doors; good light and ventilation; halls square, broad, light; stairs neither steep nor dark; every one of them fireproof; separate bathroom arrangements for each family; courtyard not less than twelve and a half feet wide and twenty-eight feet long; light everywhere, so that dust and rubbish show plainly and microbes have little chance.

Parks, Playgrounds, etc. Every important city in the land is bending its energies in the direction of sanitary surroundings for all the citizens. Such surroundings require clean streets and sidewalks, and the prohibition of spitting; houses with modern plumbing, and with an abundant supply of sunlight and air; protection from microbe diseases; parks and playgrounds where children may exercise in fresh air and sunshine; public baths where, at little cost, citizens may refresh themselves through cleanliness; water from sources uncontaminated by human wastes; food which must come up to a fixed standard of purity and be passed upon by city inspectors; pure milk from tested cows.

In most cities the board of health tries to give to its citizens all these good things, and it is for us to find out



Swimming Pool, New Curtis Hall Building, Jamaica Plain (Mass.)
Indoors the year round

what is being done by our own board of health for the protection of ourselves and our neighbors.

The Sewage System. Even go as far as to find out about the sewage system of your town. Learn how the sewage is gathered, where it is deposited, and find out whether there is any risk of spoiling the water or the air for other people. Remember that flies go where filth is found, and that if sewage leaks, flies will discover it and will bring disease germs from it into your home. Careful disposal of town and city sewage is one of the most important of sanitation duties. And what of sanitation and our food supply? Here country and city alike are helped by our national pure-food laws.

Pure-Food Laws and Food Inspection. In 1906 the government of the United States passed what are known as the pure-food laws. Even before this, however, many cities had their food inspectors, who hunted out and destroyed unfit food. Not so very long ago the food inspectors of Cleveland, Ohio, sent 2500 pounds of unfit meat from the market to the garbage plant. Later the health officers of the same city seized 38 cattle, 29 hogs, 4 sheep, and 5 calves, telling the owners that the animals were diseased and not fit to be sold for food. In 1907 the inspectors in New York City discovered and destroyed 362,795 pounds of groceries and canned goods which were unfit for use. So the experiences of different cities might be multiplied.

Danger from Dyes. One inspector writes: "I have seen candy samples brought to the laboratories and boiled down; then rags were dipped in the stuff, and after the rags were dried no amount of washing would remove the dye." Dr. Kellogg says that "a single glass of raspberry soda such as is found at soda fountains was found to contain sufficient coal-tar dye to color two yards of woolen cloth." Now the objection to these coal-tar dyes is that some of them are harmful. It is best, therefore, to omit them from our fruit, our candies, and our bright-colored drinks. If you feel suspicious of any special bright-colored canned fruit, test the liquid for yourself. Dip a bit of clean white cloth into it and let it dry. If the color will not wash out, you should report to a food inspector. He will follow the matter up and decide whether or not the color is due to the fruit itself or to a dye.

Canned Food. Food canned in tin should never be left in the can after it is opened. Canned meat should be used the day it is opened, because it decays soon. Our food supply is really safer than it has been for years, because food inspectors are on the watch. There is a standard set by law for every article of food we use —for flour, sugar, tea, coffee, canned meats, canned vegetables, canned fruit, honey, molasses, butter, maple sirup, and all the rest. And the duty of the inspector is to see that what is sold corresponds with what the law requires. Many meat markets, fish markets, bakeries, and groceries that were careless before are now required to be clean and to keep the food they sell safe from flies, dust, and soiled hands. In some places hands are not allowed to touch bread after it is baked. The pure-food law also requires that the label on medicines, sauces, catchups, and preserved fruits or vegetables shall declare exactly what ingredients are in them.

Patent Medicines. At the great exposition in San Francisco, in 1915, the American Medical Association had a special exhibition to show how much alcohol there is in different kinds of patent medicine. It was a sorry sight. For by its exhibition the Medical Association showed that almost all patent medicines are worse than useless, and that he who buys and uses them runs the risk of injuring his health seriously.

No disease of man causes more despair in our towns and cities than tuberculosis. We therefore turn now to study its cause and the way to prevent it.

QUESTIONS

1. What should be the condition of barn, stable, hen yard, and other outbuildings in the country? 2. Where should the well be placed? 3. How about cleanliness in the city? 4. Visit some crowded part of it and describe what you find. 5. What about tall tenements, dark halls, unpleasant odors, leaking gas pipes, broken sewers? 6. What three conditions are best for microbes and worst for men? 7. What three things must people guard in connection with their homes? 8. How may the air be kept pure? 9. Why should water be kept pure? 10. What is the modern watchword for every community?

11. What do people do with their garbage in the country? in the city? 12. What do people do about their sewage in the country? in the city? 13. What do people do with their dry wastes — their rubbish — in the country? in the city? 14. What about street cleaning in

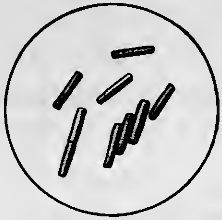
country and city? **15.** Who is responsible for a man's drinking-water in the country? in the city? **16.** In these five sets of contrasts, who seem to have the easiest task in keeping their surroundings sanitary, people in the country or people in the city? **17.** What can you say about the need of sunshine and fresh air for everybody? **18.** What chance for this is there in the country? in the city? **19.** Why are some city streets like narrow, sunless valleys? **20.** How much sunshine do children get who play in the streets of certain cities? **21.** What are rear tenements? **22.** Describe the requirements of the new law for tenement houses.

23. When we speak of sanitary surroundings for citizens, what do we mean? **24.** What power has the board of health in most cities? **25.** What good conditions and what bad conditions are to be found in your own town? **26.** Tell what you can about pure-food laws and food inspection. **27.** What can be said about the use of coal-tar dyes in foods? **28.** What articles of food have a standard quality set for them by law? **29.** How safe are patent medicines?

CHAPTER XXI

OUR FOE—THE TUBERCLE BACILLUS

Ravages of Tuberculosis. Perhaps no discovery connected with the lungs has ever interested the thinking people of the world quite so much as that of Dr. Robert Koch in 1882. This man was a German scientist, and when he declared that he had found the microbe which kills more human beings each year than any other one disease, the news seemed almost too good to be true.



TUBERCLE BACILLI
Three thousand put end to end will measure one inch

The fact is that, until 1882, no one knew the cause of tuberculosis, or how to prevent it. Yet, in all lands, doctors have been and still are appalled at the death rate that follows wherever the disease goes. By studying the records they see that, each year, in New York City alone, 10,000 men, women, and children die of tuberculosis; that, in the United States as a whole, 500,000 people are constantly ill with it; that 150,000 of this number die each year of tuberculosis; and that in the world at large, there is about the same death rate from the same disease. Moreover, it is evident that the ranks are quickly refilled by those who were well, but who in some mysterious way have been stricken with the disease. Doctors also realize that in the whole world about 1,000,000 people are killed by tubercle bacilli each year.

Dr. Koch's Discovery. In the past the saddest part of the situation was that when a person found he had tuberculosis he felt helpless about it. He thought the chances were all against his getting well again. He even thought there was little to do but to get ready to die. Imagine then the great hope that sprang up everywhere when Dr. Koch announced that he knew where tuberculosis came from and how men might escape it. He said he had made the discovery by the use of his microscope, and that what he found was a living and growing thing. He gave the microbe a name — tubercle bacillus; studied its size and shape; noticed its habits; watched it multiply; learned how it may be conquered in the human body and also saw what conditions favor its rapid growth. Knowing as he did that each one of his discoveries would help save the lives of men, he published his conclusions promptly. Here are a few of his facts stated in close succession.

1. Each separate bacillus is a separate plant.
2. Each is small and slender like a tiny rod.
3. Three thousand of these microbes put end to end will measure one inch.

4. Each multiplies by dividing.

5. The only place where they can multiply is in the bodies of men and animals, or in laboratories where scientists raise them.

6. After they leave the body they live, but apparently they cannot multiply.

7. They live best in damp, dark places.

8. In such places they keep alive from a few weeks to two years.

9. Bright sunshine kills them in a few hours.

10. Boiling kills them at once.

11. Cold does them no harm.

12. They can live and float about in the driest dust.

13. They may cause tuberculosis in any part of the body.

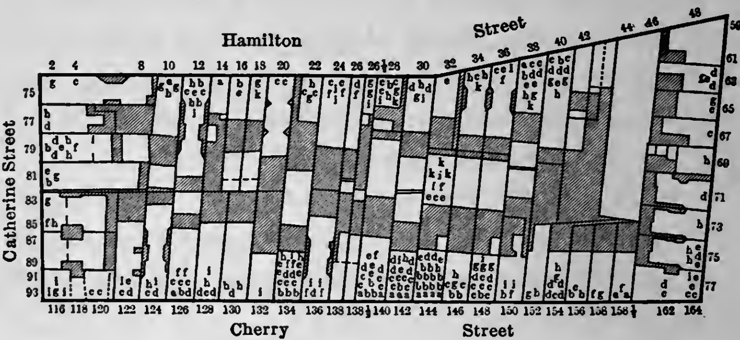
14. They cause it in the lungs most often.

15. Tuberculosis of the lungs is what we call consumption.

The discovery of all these facts, one by one, was exciting to every doctor, every scientist, and every consumptive who heard about them; for each one knew that a turning point had come in the history of the disease, and that there was hope now for thousands of people who had been hopeless before.

It was also clear that all sorts of people were exposing others to the disease every day, and that each one was blameless, for until Koch's great discovery no one knew the facts about the tubercle bacillus. Now, however, various earnest men and women learned these facts and studied the history of tuberculosis both in the country and in the city.

Records from "Lung Block." They found that, as a rule, there is more consumption in places where people



"LUNG BLOCK"

The shaded parts show courts and air shafts. Each letter stands for one case of consumption reported since 1894. All the "a's" belong to 1894, the "b's" to 1895, the "c's" to 1896, etc., up to 1903

are crowded together in dark rooms than anywhere else, and that even in such places there is the greatest difference in special houses and special rooms. This was the case with what was called "Lung Block" in New York City. From these houses, during nine years, two hundred and sixty-five cases were reported to the health department, and very many more were unreported. Single rooms also told their sad stories.

Mr. Ernest Poole, who studied the subject thoroughly, made a printed report of one of these rooms, covering a seven-year period. He says the room was on the third floor, looking down into a court, and that in it people died of consumption steadily, one after the other.

1. A blind Scotchman, in 1894, had consumption, went to the hospital, and died there.
2. His daughter had consumption and died.
3. One year later a Jew was taken ill there and died in the summer.
4. A German woman took the disease and died.
5. An Irishman was the next victim. He was weakened by overwork, caught the disease, fought against it bravely, but died in 1901.

East-Side Conditions. Another house on the East Side of the city had dark halls where one needed to grope his way about, seventy small rooms with almost no outside air and light, and an air shaft partly filled with rubbish and filth. One hundred and fifty people lived in that house and died fast of consumption. In the middle apartment on the second floor, five families were lodged one after the other for four years. One of the first family died, two from the second, and one from the third, while two members of the fourth family died in the hospital after leaving the place.

Surely, the saddest part of such a record as this is the ignorance of the victims themselves. When they first visit the house, they notice nothing more objectionable than darkness, dirt, and close air. They discover no microbes, suspect nothing, and decide to come to the rooms to live. They do not know that the chances are that some of them have come to those rooms not to live but to die.

Now how does it happen that, over and over again, in every crowded city, after there has been one death from consumption in a house other cases are almost sure to follow, and then still others again, for years and years afterwards?

The Tubercle Bacillus: how Lodged and Distributed. The whole explanation is in the nature of the microbe, the tubercle bacillus itself. Those who examine the room can of course see no sign of these microbes, yet there may be millions of them in the dust, in the cracks of the floor, on the walls and the ceiling, or hidden in the folds of the curtains. Often all they need is to be stirred up by a broom that has not been dampened or to be flourished about with a feather duster; for in either way they are tossed into the air and are ready to do their mischief.

Dry dusting is bad. It simply lifts the microbes from the spot where they are quiet and harmless and scatters them in the air, where they threaten all who breathe it. Damp or oily dusters are best. Wet sawdust or torn-up damp paper scattered on the floor before sweeping will keep the microbes from being scattered.

After microbes once reach a room, they will live there for months and even for two years unless the place is thoroughly disinfected. This work of disinfecting a room or a house is so important and needs to be done so thoroughly that in almost every case a doctor or a city official must attend to it.

The Nature of the Microbe. The very nature of the microbe explains all this. It has no mind. It makes no plans. It simply lives on when nothing kills it and multiplies when it finds favorable surroundings. Yet it never goes hunting for a home, for it cannot move about of itself. On the contrary, if it is in the air, the wind may drive it anywhere, and it will stay where it is tossed until something starts it moving. It is so small that a man may breathe it with the air. It may escape all the cilia and the mucus of the air passages and safely reach the spot where it grows the best, the lungs of a human being.

Bacilli in the Lungs. Here everything is favorable. The place is warm and moist, the delicate tissue is good ground to grow in, and the microbe begins to multiply promptly.

Yet there is another side to the situation. The lungs themselves seem to make a protest. They like the microbe no better than a human eye likes a bit of cinder. At once, therefore, certain cells of the lungs hurry to the spot, surround the microbe, and try to build themselves into a wall about it. In a way it is a sort of contest, and at last the multiplying microbes and the cells are bunched together in a hard lump called a tubercle.

Sometimes the cells of the lungs are vigorous enough to fasten the microbes up so securely that they cannot multiply. In this case they become harmless, and the man does not have consumption. At other times the microbes prove to be the stronger. The tubercles then increase, the man's lungs gradually become useless, and finally he dies.

Danger from Sputum. Always the peril to other people is from what a tuberculous person coughs up. It seems that, as each tubercle grows larger, the center of it softens, and the person must get rid of it. This is the sputum. Often it has a yellow color and is full of the microbes themselves. The worse off a man is, the more he coughs and expectorates; and the more he expectorates, the more of the living, dangerous microbes he sends into the outer world.

Those who know about it say that a man with consumption may expectorate two or three billion tubercle bacilli every twenty-four hours.

Tuberculosis of the Bones. Instead of tuberculosis of the lungs, young children are more apt to have tuberculosis of the bones, which gives them crooked backs and hip disease. This is often cured by skillful doctors.

Consumption not Inherited. Fortunately, however, no one inherits any kind of tuberculosis. To be sure, children of consumptive parents often have it, but they may have every chance to take it after they are born; for they may live in the same house with their careless, consumptive parents, may touch the same things, breathe the same microbe-laden air every day, and may even creep about on the floor, where dust and microbes are thickest. Worse yet, without intending the slightest harm, those parents may even kiss their children on the lips. They do not know that this should never be done.

With thousands of careless people coughing and expectorating every day for months and for years, it is easy to understand how streets and houses, rooms and people, may become infected; for each new case of a person who is careless with his sputum means more microbes to shift about, and at a moment's notice they are ready to go back into the lungs of any human being. After that, the vigor of those lungs themselves is the only thing that can save a man. This explains the importance of the great war between man and the microbe which is now being waged.

War against the Enemy. In 1907 the Maryland Association for the Prevention and Relief of Tuberculosis had an exciting campaign. Its rally call was, "Will you help build the fence?" And for twenty-three days this mystic query appeared in large letters on every street car in Baltimore and on nearly every blank wall; even the ash cans did not escape. At first there was puzzled curiosity on the part of those who saw the sign;

**WILL YOU
HELP
BUILD THE
FENCE
?**

next came interest; and when the meaning of the question was discovered, when all knew that it meant a "fence" of prevention to protect people against consumption, there was such enthusiasm that in less than three weeks ten thousand dollars were raised for the use of the association during 1907.

This, then, is the sort of warfare that is going on in Maryland and elsewhere in the world to-day. Now that we have actually found the foe, now that we know both how to kill him and how to protect ourselves from him, we are pledging ourselves to do it. We know that there are just two ways by means of which the world may banish tuberculosis:

1. *By destroying the microbes* which start the disease.

2. *By making human bodies vigorous* enough to resist the microbes.

In conducting this campaign, let the triple motto be:

1. *Tuberculosis is preventable; we will prevent it.*
2. *Tuberculosis spreads; we will check it.*
3. *Tuberculosis can be cured; we will cure it.*

The Anti-Tuberculosis Crusade. With this as their motto men and women in all lands are now carrying on a world-wide anti-tuberculosis crusade. They are printing and distributing leaflets by the hundred thousand and the million, for they are determined that those who are well shall know how to protect themselves from the microbes of those who are ill, while at the same time those who are ill shall know enough not to pass their microbes on to others.

The sad fact is that multitudes of people are ignorant both about giving and about taking the disease. Nevertheless it is as true to-day as it ever was that the person who breathes dust loaded with tubercle bacilli is in danger of tuberculosis, and that the only way to escape the danger is to keep the lungs healthy and not to breathe such dust.

Yet how shall we keep from doing this?

Careless people leave their deadly sputum in crowded rooms, cars, theaters, stations, and saloons. It then passes through all the stages of drying, being crushed, turning to powder, and getting into the air; and afterwards, in each of those places, people must breathe the contaminated air. In a dusty city street a man breathes anywhere from ten to four hundred microbes a minute, according to the place he is in; and the larger the number the greater the chance that tubercle bacilli are among them.

Carelessness in Public Places. When, therefore, you see a man expectorate carelessly on street or floor, you have a right to say to yourself: "One thing is plain — either that man is absolutely ignorant or absolutely selfish; either he does not know the laws of health, the habits of the microbe, and the laws of the city against spitting, or he is willing to run the risk of giving a deadly disease to his fellow citizens."

Of course it is true that saliva without tubercle bacilli can do no harm, but city officials know that what the well man does the ill man is sure to do. For this reason laws against spitting extend to everybody — young and old, well or ill — who comes where they are in force. Many cities post their laws in cars, stations, and all public places, and they enforce them or not according to their zeal for the welfare of their citizens. Here is a New York notice:

> Spitting on the floor of this car is a misdemeanor. A fine of $500, or imprisonment for one year, or both, may be the punishment therefor.

Some cities are so much in earnest about this matter that men in tall silk hats as well as those in shabby derbies have been fined for breaking the law.

Public Sentiment. A few years ago very few people protested; few even noticed the spitting. Now, however, the man who spits is noticed by a dozen different people at once, and each one looks upon him as either a deserter from the camp of good citizens or as a person ignorant of the laws of health.

Rules of Prevention. For his own sake, therefore, as well as for the sake of his city, each loyal citizen should practice the following rules of prevention:

1. Never spit in a place where sputum may dry and get into the air.
2. Use paper or cloth and burn the sputum before it dries, or else use a spittoon that has water in it to prevent the microbes from drying and floating around in the air. Clean the spittoon often.
3. If there is a persistent cough and a good deal of sputum, tell the doctor about it. He will have the sputum examined.

Every doctor in the land knows how important this last point is, for the secret of curing consumption is to discover it when it begins, and the most usual way to do this is to examine the sputum for tubercle bacilli.

Cure for Tuberculosis. This disease is really somewhat like a fire in a lumberyard. If the fire is discovered when it starts, a single pail of water will dash it out; but if it is left until the whole lumberyard is blazing, even the fire department cannot save the lumber. So too with tuberculosis. Three quarters of the cases found early and taken care of are cured, while the cure itself is often as simple as the fire cure, although in the case of consumption four things are needed instead of one.

1. *Fresh air* from morning until night and from night until morning.

2. *Sunshine.*

3. *Wholesome food*, with fresh milk and eggs.

4. *Rest* for body and mind.

If the patient discovers the disease soon after he takes it, and if he can get those four things, he will probably recover; if he cannot get them, he will probably die.

Safety for Others. Consumptives who are careful about their sputum are not in danger of giving consumption to others. They may live under the same roof with them, work side by side, breathe the same air from day to day, and yet, from first to last, if they destroy every drop of their sputum, other people are not in danger. As tubercle bacilli never fly away from a damp surface they stay in the throat and air tubes of a consumptive and are not expelled in his breath unless he breathes hard or sneezes. If he does either, he should hold a cloth before his mouth and burn it immediately or have it boiled.

Five Tuberculosis "D's." Any person with a vigorous body is best able to resist every sort of disease microbe. To secure such a body, let each of us learn to shun what have been called the five tuberculosis D's — *dirt*, *darkness*, *dampness*, *dust*, and *drink*. Let us also practice the golden rule of the anti-tuberculosis leagues:

Don't give consumption to others.

Don't let others give consumption to you.

Those who understand tuberculosis best speak very positively about using medicines for it. They say:

1. No medicine has yet been found that will cure consumption.

2. Advertised medicines often contain alcohol, which hastens consumption.

3. No person with consumption can afford to run the risk of taking any advertised medicine.

4. In taking medicine, a consumptive should follow the advice of a good doctor.

Then too, from first to last, they should ever seek those four best things—fresh air, sunshine, wholesome food, and rest.

Outdoor Air. In the country as well as in the city, men need to know both how to prevent tuberculosis and how to cure it if it has made a start. Wise people will see to it that windows are open in their homes, their shops, and their schoolhouses. They will keep them open by night as well as by day, for they will know that less dust is being stirred up at night, and that night air is therefore the best air to be had.

At the same time they will make sure that their bodies are warmly covered when they sleep in cold rooms full of fresh air. An inexpensive way to get extra covering is to sew newspapers between blankets. Paper does, in fact, keep cold out so well that in some places paper blankets are manufactured, and they can be bought by the dozen at a very low cost. Keeping warm enough and breathing fresh air must go hand in hand.

In a city even hospitals have trouble in giving a man all the air he needs. Windows are kept open, and reclining chairs are put on the roof for certain patients to use. Other patients breathe fresh air even in bed,

Fresh Air on the Roof in a City

for the cot itself, with the patient, is thrust through an open window into the air and sunshine. But a sanatorium or a tent in the country is best of all for a tubercular patient, because in such places every needed thing is at hand.

Some consumptives do not have tents, but actually sleep out of doors in midwinter.

Sleeping Outdoors in Winter. Professor Irving Fisher says he did this when the temperature was ten degrees below zero. He also says that in the winter of 1904, in the Adirondack Cottage Sanatorium, six people slept outdoors when the temperature was thirty degrees below zero. They had two or three mattresses under them, warm blankets and comforters over them, heavy night

FRESH AIR AND SUNSHINE TO CURE CONSUMPTION

clothes about them, and also woolen headgear with an opening for the nose.

Each person knew that the more fresh air he could get, the more chance he had to live. It even seemed as if the colder the air the better they felt.

Open-Air Classes. It is because of these facts that what are called open-air classes are springing up in many places. Those who start the classes know that every chance for life and health is increased for children who have been attacked by tubercle bacilli if they can do their studying out of doors and not within the four walls of a schoolroom.

In this great anti-tuberculosis war, town and country people are sure to be victorious in the end, but how soon the end will come depends on whether or not the children of the world understand how serious the danger is, and whether or not they are willing to join the forces that fight tuberculosis in every land.

Let us all remember that prevention is better than cure, and that fresh air is as important to keep us well as to help cure us after we are ill. Let us make sure that fresh air gets into our homes by day, and that we sleep in abundance of it by night. Let us do what we can for our general health and thus help save ourselves from the foe without wings that comes floating to us in the air we breathe. And what of that other foe which may reach us in a glass of clearest-looking drinking-water? We turn now to typhoid microbes and study them in their natural surroundings.

QUESTIONS

1. What was Dr. Koch's great discovery in 1882? 2. What causes consumption? 3. What is the annual death rate from tuberculosis in the United States? in the world? 4. In past times what has been the saddest part of the situation? 5. How did Dr. Koch's discovery bring hope? 6. Is each separate tubercle bacillus a plant or an animal? 7. Tell of its shape, size, how and where it multiplies. 8. How many

of them put end to end will measure one inch? **9.** In what kind of places do they live best? **10.** How long can they live? **11.** How does bright sunshine affect them? intense heat? intense cold? **12.** What becomes of them in the driest dust? **13.** To what parts of the body can tubercle bacilli give tuberculosis? to which part most often?

14. What is the common name for tuberculosis of the lungs? **15.** Where is most consumption found? **16.** Describe "lung block." **17.** Mention ways in which one case of consumption leads to other cases. **18.** Describe the conditions found in a New York East-Side house. **19.** Where do microbes stay? **20.** How do they reach the air from their lodging places? **21.** What objection is there to dry sweeping and the feather duster? **22.** What should one use instead? **23.** How does the microbe get into the lungs? **24.** What favorable conditions does it find? **25.** In what way do the lungs seem to protest? **26.** Why is sputum dangerous? **27.** How many tubercle bacilli may a consumptive person expectorate within twenty-four hours? **28.** What articles may hold them? **29.** What may become of them afterwards? **30.** How many people inherit tuberculosis? **31.** How do children of consumptive parents get the disease? **32.** So far as tubercle bacilli are concerned, what especial advantage is there in having vigorous lungs?

33. Describe the anti-tuberculosis war in Maryland in 1907. **34.** Mention two ways by means of which the world may banish tuberculosis. **35.** Give the triple motto of the campaign. **36.** Why do we make laws against spitting in public places? **37.** Give the New York law. **38.** Why do we compel healthy people, as well as those who are ill, to observe the law? **39.** What rules of prevention should every loyal citizen practice? **40.** In what way is tuberculosis like a fire in the lumberyard? **41.** What four things are needed to cure consumption? **42.** Mention the five tuberculosis "D's." **43.** What is the golden rule of the anti-tuberculosis leagues? **44.** What can you say about using medicine for consumption? **45.** When sleeping in cold, fresh air, what must be done about keeping warm? **46.** How do city hospitals manage to give their patients fresh air?

CHAPTER XXII

THE CHOICE: PURE WATER AND CLEAN MILK OR TYPHOID MICROBES AND TYPHOID FEVER

Former Conditions in Pittsburgh. Year after year, for thirty-five years, people died in Pittsburgh, Pennsylvania, under the scourge of typhoid fever. As the city grew, the number of deaths multiplied until, in 1907, 622 people died of typhoid alone.

But the misfortune was greater than this; for, besides those who died, there were thousands of other people who suffered but did not die. Hundreds at a time were ill in their homes and in the hospitals of the city. They lost money because they could not work for daily wages. They paid out for doctors' bills and medicine savings that were intended for food, fuel, clothing, and house rent. Thousands of children were hungry and cold because their parents were too ill to care for them and too weak to work. It is indeed estimated that for each person who dies of typhoid fever eight other persons are ill with it.

Explanation of the Death Rate. So matters progressed from bad to worse for thirty-five years. In the meantime a generation of people came and went. And what was the explanation of this death rate? Just one thing. The drinking-water of Pittsburgh. Why, then, did the citizens use it? Because at that time multitudes of people did not know the facts about pure and impure drinking-water. They did not know that every case of typhoid fever is started by a small living thing which comes from the body of some one who has the fever. They did not know that this microbe is harmless unless it gets into our mouths and we swallow it alive. They did not know that their own drinking-water was loaded with living, active typhoid microbes which had come direct from the bodies of other people. They did not even know that boiling kills disease microbes, and that any boiled water, no matter how wretched it looks, is safe to drink because it is free from living typhoid microbes.

And just because they were ignorant, multitudes of honest, hard-working people in Pittsburgh took city water as it came from the faucet and drank it without fear.

How Typhoid Microbes reached Pittsburgh. Perhaps we wonder why this particular water was so full of the microbes. Any map of that section of the country helps us to find the explanation. Notice the location of Pittsburgh. See how it lies at the point where the Allegheny and Monongahela rivers join to form the Ohio. Follow the two streams upward and notice that all the way along towns and cities are ranged on both banks of both streams. There are over seventy-five of these groups of houses, and their united population gives a total of over 350,000 human beings. This, then, throws light on the entire water problem of Pittsburgh, for it turns out that each of these towns and cities pours all its waste water, its sewage, into the river on whose banks it stands. A most natural riddance of it surely, for the river carries off the waste, taking it downstream. But think of the next step in this water history.

Towns that contaminate Drinking-Water

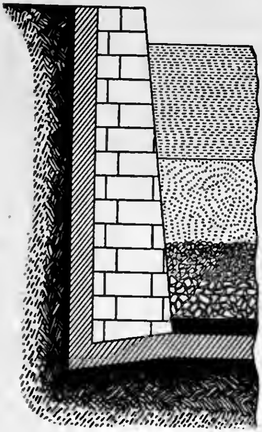
Not only does each town empty all its sewage into the river, but each town also takes all its drinking-water from the same river. In other words, the *sewage of each town becomes part of the drinking-water of all the towns that lie farther downstream.* Naturally the mixture grows constantly worse, and by the time it reaches Pittsburgh it is fearful stuff to drink.

Nevertheless, just as it was, without any pretense at killing the microbes or taking them out, this liquid compound of water, waste, and filth was in those days turned directly into the huge water pipes of Pittsburgh, and the masses of the people drank it with no suspicion of danger. Had they known the peril and the way of escape, they would have saved themselves.

Microbes and Drinking-Water. We ourselves know that if there are no typhoid microbes in our drinking-water, however wretched its color and taste may be, it cannot by any possibility give us typhoid fever. We also know that however clear and sparkling it may be, if there are typhoid microbes in it, disease and death may go to the one who drinks it. In the case of Pittsburgh, many persons upstream had typhoid fever, and their sewage, with its load of microbes, was poured into the stream and sent from city to city as the stream rolled onward. Pittsburgh suffered most simply because it was farthest downstream and had therefore received more sewage in its drinking-water than any other place.

Safety through Sand Filters. Then came an abrupt, astonishing change in the death record. During the single month of October, 1907, 596 persons had been ill with the fever. But during the month of October, 1908, there were but 96 cases of it in the city; and deaths for the entire year dropped off in like proportion. This changed record has continued to the present day. And the explanation of the entire change rests with the sand filters which were set to work in 1908. These filters are near the city, 46 in number, and worth visiting. Each covers an acre of ground; each is about five feet deep;

each is a separate bed of pebbles, gravel, and fine sand — pebbles on the bottom, sand on top. River water is turned on these filters. It soaks through slowly and is carried in water pipes to the homes of Pittsburgh. Nothing could be more unpretentious and matter of fact than those huge sand filters.[1] Yet they are the life-saving stations of the city. They purify the water and, by so doing, save hundreds of lives each year. Scores and scores of towns and cities are saving themselves by the same sensible method. At the same time, multitudes of other townspeople are drinking unsafe water. Most of them do this ignorantly.



SAND FILTER

From coarse gravel to fine sand

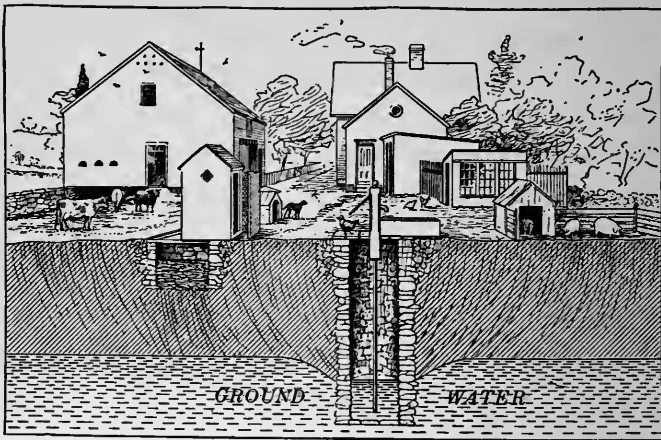
Now think for a moment of the water conditions in your town. Where does your drinking-water come from? If from a river, study some map and try to decide whether or not other people farther upstream are sending their sewage down to you.

[1] Multitudes of microbes live and multiply on the surface of large, out-of-door filters. They find their best food in the worst kind of water and sewage. When water is poured upon a filter bed, these hungry microbes take the impurities out, and also destroy disease microbes — and other kinds too — that were in it. After this, the water is safe to drink. Thus it is that microbes on the sand purify our water for us, and save us from disease microbes.

If so, when typhoid fever attacks any person in that town, you yourself will be in danger. Clearly enough, then, all river water that is exposed to human contamination should be either boiled or sent through outdoor sand filters before it is used as a drink. A small filter in the house does not purify water in the same way. It takes out dust and color, but it does not remove disease microbes.

Lake Water for Drinking. Perhaps your drinking-water comes from a lake. If no human beings send sewage of any sort into that lake, water from it may be used fearlessly as a drink. Generally, however, large lakes receive much sewage from houses and towns that stand on their shores. For safety's sake, then, such lake water should be either boiled or filtered.

Danger from Well Water. Perhaps you draw water from a cool country well and feel very safe as you drink it. Still there may be danger even here. For example, two friends enjoyed what they considered delicious water from a country well in northern Ohio. One month later both men were down with typhoid fever and one of them died. What was the trouble? Those who examined the surroundings afterwards saw that the well was too near the dwelling house to make it safe. Water from the surface of the ground found its way into the well, and with it had gone sewage from a man who had had typhoid fever in the house. The water itself was cool and clear as crystal. Neither by its taste, its color, nor its odor did it tell any tales about itself. Dangerous microbes were, however, concealed in it. This peril from well water is so real that many a village which depends



DRINKING-WATER FROM A WELL

Notice that both well and cesspool are near the house. The contents of the cesspool soak through the ground without hindrance and contaminate the water which supplies the well. If typhoid microbes are in the cesspool, they will get into the drinking-water

(From *The Human Mechanism*, by Hough and Sedgwick)

on wells is more in danger from typhoid fever than are large cities which supply themselves with water brought to town through pipes from some pure though distant source.

Sources of City Water. Judging by the facts, then, it begins to look as if water were encompassed by danger. So it is wherever sewage from man can in any wise reach it. For this reason we have all grown more careful about the sources of our water supply. Some cities draw it from mountain springs and from small lakes which cannot be contaminated by man. Others build huge reservoirs and protect them. Here water is stored by the hundred million gallons at a time. Still other places yet filter such water as they are obliged to use from undesirable sources. For example, London, in England, must use water from the Thames. Yet, as this river flows by, it carries sewage from many towns on its way to the sea. Nevertheless even the terrible water of the Thames is so purified by sand filters that London is remarkably free from typhoid fever.

It is unpleasant to use unclean drinking-water, but as already shown, the real danger to life is from the disease microbes which may be in it. They may give typhoid fever and other intestinal troubles. As a safeguard against typhoid fever, doctors now inoculate people and thus protect them.

Rain Water. It is raining at the present moment, and I think of the pure water that comes from the skies. Not a microbe is in it, for microbes never ascend to the clouds when water evaporates. Floating microbes may be in the air on a dusty day, but these are washed out by the first dash of raindrops.

Everywhere in the world, therefore, rain water, direct from the sky, is safe to drink. And when this water is caught in clean tanks and kept away from all human contamination, it continues to be the safest water we have.

In deciding whether to live in this town or that, always make some inquiry about the water supply before you come to any decision as to where to make your home. For life itself depends on the purity of drinking-water.

Typhoid Epidemic from Milk. Then, too, there is that other important drink—the milk we use so constantly. Even in this there may be danger from harmful microbes. In Springfield, Massachusetts, in 1882, typhoid fever suddenly appeared in several different homes at about the same time. On investigation it was found that all who had the fever took milk from the same milkman, and a little later it also appeared that a man had just had typhoid fever in the milkman's home. Just how the microbes reached the milk no one could say. Perhaps the milk cans were washed in contaminated water. Perhaps typhoid microbes were on the hands of the man who did the milking. However it was done, there was no doubt about the fact. In one way or another typhoid microbes had reached the milk and passed the disease on. Scarlet fever and other diseases have sometimes been carried in the same way. But it is typhoid microbes that threaten milk most frequently.

Conditions of Clean Milk. In the town where I live there is just now quite a rivalry in the milk business. Two men are trying to outdo each other in the perfection of the milk they deliver. On one neat-looking

A Model Dairy

Clean cows, clean stables, and clean milk

milk wagon the printed sign reads, "Clean Milk Dairy"; on the other there are but two words, "Pure Milk." As for ourselves who buy the milk, we know that from both wagons the best of milk is delivered to us. We are sure of this because both dairies believe in cleanliness, and try to secure it. They know that *the* *cleaner the milk the fewer the microbes, the fresher the milk the fewer the microbes, the colder the milk the fewer the microbes.*

In both dairies, therefore, clean cows are kept in clean stables; they are milked by clean men, who wash their hands before they do the milking. Clean pails, clean pans and bottles, all are kept fresh and sweet through the use of boiling water and "live steam." Those who conduct this business know that microbes multiply faster in warm, unclean milk than elsewhere, and that each speck of mud, each bit of horsehair, that enters the milk carries countless microbes with it. They also know that each of these microbes begins to multiply at once and that no amount of straining can take out microbes after they are once in a liquid. These men are therefore wise enough to be careful of the milk supply from the time it is drawn until it is delivered. In addition, they keep it cool from start to finish.

Unclean Milk. It is quite otherwise, however, with certain men who carry on the same important business in a neighboring town. They do not seem to know that dirt and microbes go together, that *the more dirt the more microbes*, that *the older the milk the more microbes*, that *the warmer the milk* (*before it is cooked*) *the more microbes of many kinds will be in it.* As a result their milk is not such as we should wish to use.

Boiling Milk to kill Microbes. If at any time you are not sure about the history of your milk supply, and if you wish to make it perfectly safe, remember the old

CLEAN MILK FOR ROCHESTER BABIES

lesson that boiling kills microbes wherever they are. Two things may render milk harmful:

1. The presence of disease microbes which may reach it through carelessness.

2. The presence of too great a number of microbes which are harmless in themselves.

Pure Milk for Babies. For young babies this last danger is the real one. Various cities are beginning to take this fact into account and are trying to supply the babies of the city with milk which carries as few microbes as possible and no danger whatever. By means of pure milk the city of Rochester, New York, reduced the death rate of its babies from 1000 in 1892 to less than 500 in 1904. Thus one example is added to another and, the world over, fathers and mothers are learning that the kind of milk they buy helps decide what the death rate of their youngest children shall be. It is indeed the children who suffer most through the ignorance of their elders. The next chapter proves this.

QUESTIONS

1. What special disease became a scourge in Pittsburgh? 2. How many died of typhoid fever in 1907? 3. How did other people suffer from the disease even when they did not die? 4. How long did the scourge last? 5. What caused it? 6. How could it have been prevented? 7. Why was it not prevented? 8. Tell what you can about the typhoid microbe itself. 9. How does it get into the body? 10. What do towns on the banks of the Allegheny and Monongahela rivers do with their sewage? 11. Where does their drinking-water come from? 12. Why was Pittsburgh water worst of all? 13. What one thing is it that makes water unfit to drink? 14. Describe the change that came in the Pittsburgh death rate in 1908. 15. What explained the change? 16. Describe the Pittsburgh sand filters. 17. What do they do to water? 18. Where does your own drinking-water come from? 19. Why is river water generally unsafe to drink? 20. Why is water from a lake unsafe?

21. When is well water unsafe? **22.** How can sewage get into a well? **23.** What do cities do for water? **24.** Tell about London water. **25.** Why is rain water safe to drink?

26. Describe the typhoid epidemic in Springfield. **27.** Describe the difference between clean milk and unclean milk. **28.** How do microbes get into milk? **29.** Why should milk be clean, fresh, and cold? **30.** In what sort of milk do microbes multiply fastest? **31.** How can unclean and unsafe milk be made safe to use? **32.** Mention two ways in which harm may come through microbes in the milk.

CHAPTER XXIII

CAUSE AND PREVENTION, OR SAFETY FROM MICROBE DISEASES

Preventable Diseases. In every country and in all parts of the world, men, women, and children are asked to join the modern army and help wage the modern war against the following preventable diseases: tuberculosis, typhoid fever, measles, smallpox, scarlet fever, hydrophobia, whooping cough, pink eye, trachoma, malaria, yellow fever, pneumonia, the hookworm disease, and our everyday colds.

As we study the list let us bear in mind three facts:

1. Disease microbes are killing more human beings each year than are being killed in any other way.

2. Those who die of any disease are few in comparison to those who suffer from it.

3. If we were all careful enough about prevention, our preventable diseases would soon be wiped out of existence. Think of the difference this would make in the happiness and the welfare of the world. Yet carelessness often comes through ignorance. Take the following case for example:

Measles and Scarlet Fever. A boy in New York City who thought he had measles[1] went to bed, called the doctor, stayed at home for some time, then was well again and went back to school. After that he became very popular. Why? Because, as Mr. Riis says, "He

CITY OF BOSTON.—HEALTH DEPARTMENT.

NOTICE

OF A CASE OF

Scarlet Fever.

When the danger from infection has Passed this card will be removed.

Any Person removing this card without authority is liable to a fine of One Hundred Dollars.

PLACED ON A HOUSE BY THE BOARD OF HEALTH

could pull the skin off with his fingers as one would skin a cat." And he gave the largest rolls to his dearest friends. He did not know and his friends did not know that disease microbes are thick in each smallest fragment of skin that comes from any one who has had

[1] Mr. Riis, who tells the story, says the boy had the measles. But critics think the disease must have been scarlet fever, because the peeling and the danger from the skin is much greater after scarlet fever than after measles.

measles or scarlet fever. So the skin went from the boy to his friends. They took it home with them and divided it among their other friends.

Then came the climax. A great spreading epidemic broke out wherever the skin had been distributed. Many were ill; some died; all suffered. If those boys, their parents, and their friends had known the facts about measles, they would have used their brains and saved their bodies from a very preventable epidemic.

Here are a few of these facts: Both measles and scarlet fever are known as eruptive diseases because they cause eruption of the skin. After this the dead skin peels off in bits. The victim should not mix with other people until the so-called "peeling" is well over, for those harmless-looking bits of dead skin may be alive with danger, and nothing but isolation of the patient can keep him from scattering disease. It is necessary to take special care of the eyes while recovering from either scarlet fever or measles.

Smallpox. There is another contagious disease which is far more terrible than measles. In the year 1854 this disease broke out on Ponape, one of the Micronesian islands. It came from the garments of a sailor who had died there of smallpox. At the time of his death Ponape had a population of ten thousand; but six months later half of those ignorant islanders were dead and buried. The microbe of smallpox had slain them before they had had time to learn how to protect themselves from this preventable disease.

In former times people dreaded smallpox and fled from it. They knew it was contagious and realized what its results were; but they tried in vain to escape it. Though they fled, they were overtaken by it; they suffered from it and carried the marks of it on their faces until they died. They were also killed by it by the hundred thousand every year. According to a careful calculation, fifty million Europeans died of smallpox between the years 1700 and 1800.

Then at last an Englishman, Dr. Jenner, learned how to save men by vaccination. Since that time smallpox has slipped into the background of the deadly diseases of the world. The explanation is that to-day in every civilized country vaccination has been adopted as a preventive. It is true that nowadays people feel so safe that they often grow careless. Even the mothers of the children sometimes forget to have their sons and daughters vaccinated. In such cases, however, the board of health of the city or town often steps in and gives commands. This was done by New York City in 1901. Without much warning smallpox had appeared in the place. People here and there who had not been vaccinated were down with the fever and were dying. Two hundred special inspectors were appointed at once, and within six months eight hundred and ten thousand people, young and old, had been vaccinated, and the city was saved from what would have been an epidemic more frightful than that which swept over Ponape. For in a city human beings are crowded so close together that microbes have a chance to spread fast. Vaccination is, however, such a sure road of escape that certain cities compel all the children to be vaccinated before they let them go to school.

Diphtheria. Here, also, we have a swift-moving disease which seems to fly from house to house through the power of an unseen foe. We ourselves know that in this case too the invisible power is a microbe, which takes its start within the throat and is able to kill its victim.

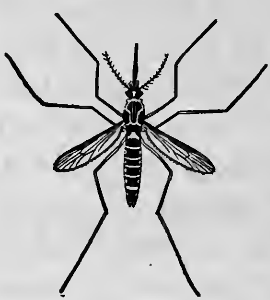
As it happens in any attack of diphtheria, life depends on the speed with which prevention can overtake the microbe as it multiplies. A child has a sore throat, then a fever. The doctor is called, and if he finds all the signs of the dread disease, he knows that his one hope is to kill the microbes before they can kill the child. Without a moment's delay, therefore, he uses the one great cure for diphtheria — antitoxin. He not only puts this into the body of the child who is ill, but also gives it to each person who has been anywhere near the child. Indeed the infection itself passes so swiftly from one to another that the only safety is to use antitoxin on all alike. It not only helps cure the one who has the disease, but also protects those who have been exposed to it. In previous times about forty of every hundred who had diphtheria died of it. Now it kills not more than eight in each hundred. The difference in the death rate is explained by the power of antitoxin to save those who have been attacked by the microbe.

Hydrophobia. In still another terrible disease, antitoxin of another sort plays an important part.

Not long ago the newspapers reported the sad case of three persons who had been bitten by a mad dog in a country town. He had been a good-natured dog, and no one suspected danger until he had bitten one boy and two men. He was then caught and mercifully killed. And what of the men and the boy? The doctors in the place knew that there was hope of life for them if they could be treated with an antitoxin prepared for just such cases, for it destroys the power of hydrophobia microbes after they have been put into the body by the teeth of a mad dog. All three of the victims were therefore hurried to Chicago. There they were treated at a special hospital for such cases. One man had been a little slow in arriving, and he alone suffered from the disease. The other man and the boy were saved by the antitoxin, which was given in time. Perhaps no suffering is more dreadful and no death much sadder than that which comes through hydrophobia. But in these days this disease is preventable, for large cities in all parts of the civilized world prepare antitoxin and supply it to the doctors when needed. This method of cure was one of the great discoveries of Louis Pasteur, the French scientist.

Dogs are not the only living creatures that put microbes into man by cutting through his skin. Turn to the havoc which mosquitoes have wrought.

Yellow Fever and Malaria. In 1793, within the space of six and a half weeks, one tenth of the population of Philadelphia died of yellow fever. Naturally, of course, the city was in a panic. No one knew what started the fever nor how it traveled from one person to another. But, thanks to science once again, we now know that if every mosquito of a certain kind were banished from the earth to-day, no human being would ever again be killed by yellow fever. It has been proved that stegomyia mosquitoes are the only yellow-fever agents in the world. By their sting, provided they themselves have already stung a yellow-fever patient, they pass the disease along. Malaria is another disease whose contagion is carried by mosquitoes alone. A person who was never stung by the anopheles mosquito would never have malaria. But that same anopheles must first sting a malarial fever patient before he himself will have the microbes to pass along. Other kinds of mosquitoes do us no harm



Stegomyia Mosquito that carries Yellow Fever whatever, but all kinds look so much alike that our path of duty is plain. We must therefore try to keep from being stung by any kind of mosquito. In order to banish them, we must prevent their eggs from hatching, must get rid of standing water where eggs may be laid, and must destroy all mosquito wrigglers. Many cities are doing these things. Small ponds and marshy places are drained or filled with earth. Barrels and tanks holding water are closely covered. Cans, bottles, and discarded kettles which might hold water after a rainstorm are not left where mosquitoes can reach them. Kerosene oil is poured over ponds containing eggs and wrigglers. This oil suffocates the wrigglers before they have time to turn themselves into full-fledged mosquitoes.

MOSQUITOES

Above is anopheles that carries malaria. Below is culex, the common, harmless mosquito. We know which is which by the position each takes when resting

The Hookworm Disease. So much for our flying foe, but what shall we say of the hookworm, that other foe that creeps and crawls, and bores its way into the skin? In this case our objection is to the creature itself and not to any microbes which he may put into us. Fortunately for mankind, a modern discovery shows how even hookworm disease may be prevented and cured.

The worms themselves get into the body in two ways:

1. *Through the skin.* They work their way into bare feet that tread upon them; they prick their way into the hands of those who handle them.

2. *Through the mouth* on things that are eaten or in water that is swallowed.

When they enter the body they are so young and so small that they cannot be seen except by the help of a microscope.

After they are in the body they travel hither and thither in the blood stream until they reach the long tube of the digestive canal. They like the small intestine best, and here it is that they earn their name, for they hook themselves to the lining of the tube with their mouths, suck up blood, even eat the lining itself, and finally grow to full size — half an inch long and as large round as No. 8 cotton thread. As many as three thousand of these have been found in one person.

When they are really full-grown they lay their eggs by the thousand. But these eggs never hatch within the human body where they were laid. Instead, they are sent out of the body with the other refuse, and the hatching is done in the outside world.

Later, when the young hookworms are partly grown (although still of microscopic size), they enter any human skin within reach. If they do not get the chance to do this, they are bound to die without descendants, for hookworms never lay eggs anywhere except in the bodies of living human beings.

The real objection to having hookworms within us is that they suck up so much blood for their own use that the owner of the blood suffers for lack of it. When this happens we say that he has hookworm disease.

Children suffer most. During the time that hookworms are robbing them of their blood they grow at a snail's pace and are languid, listless, and poorly developed. They have what are called pulsating blood vessels in the neck, and a tallowlike skin. Hookworms cause it all. Indeed hookworm disease affects nerves, muscles, lungs, blood and circulation, stomach and digestion.

When the worms are outside the body they thrive best in warm, moist, sandy soil. Naturally, therefore, the disease is more common in summer than in winter and far more prevalent in warm regions of the earth than in places that are sometimes wintry cold.

Very often hookworm disease starts with what is called ground-itch. In fact, the spot that itches is generally nothing but the place where the worm pierced the skin and entered the body. Sad to say, in parts of the earth that are constantly moist and warm there are to-day thousands of men, women, and children who are victims of this hookworm disease. But doctors can cure the disease and prevent its return.

1. They give one kind of medicine to kill the worms within the body.

2. They give another kind of medicine to help the body drive dead hookworms out of it.

3. They see to it that refuse which passes from the human body is put where no worms hatching out from the eggs that may have been in it can ever get into the neighborhood of human beings.

4. They teach people not to go barefoot; not to wear leaky shoes; not to put the hands into soil that may hold hookworms; and not to drink water that could have been reached by hookworms.

In doing all these things, scientists are keeping in mind two facts:

1. To prevent hookworm disease, hookworms and human beings must be kept apart.

2. The way to keep them apart is to prevent human refuse from reaching any soil which may be walked upon, and from reaching any water that may be used for drinking.

To secure these results, houses must be connected with a sewer system that carries all human waste to some distant point. When this is impossible, houses — whether private homes or schoolhouses — must each have what is known as a sanitary outhouse. In other words, the one important point is to keep the ground free from human pollution. And the one danger from this pollution is that it may have hookworm eggs in it by the hundred and the hundred thousand.

Rules for those living in Hookworm Regions. The following medical commands must be obeyed by all who live in hookworm regions:

1. Stop soil pollution.

2. Build and use sanitary outhouses.

3. Never go barefoot unless the ground is perfectly dry. To state it the other way round: always wear shoes when it is raining, when the ground is wet, even when dew is on the ground.

Going barefooted on wet ground in hookworm regions gives hookworms their chance to enter the body.

4. If you get ground-itch, go to the doctor about it at once. Always take treatment for hookworm disease within three months after you have had an attack of ground-itch.

Whooping Cough and Mumps. From such an unpleasant subject as hookworm disease, it may be a relief to turn to whooping cough and mumps. Here again we have two diseases that reach us through the air. While you have either trouble, stay by yourself or with others who suffer similarly. Do not mix with well people until the doctor allows it. Never forget that when you cough you throw impurities into the air, and that those who breathe the air afterwards will draw these impurities into their lungs. He who has whooping cough or mumps should use his own particular knife, fork, spoon, cup, and tumbler until he is altogether well — unless, indeed, he boils them all after using them. Boiling will make them safe for others to use. Perhaps the worst thing about whooping cough is that those who have it are more easily overcome by other diseases afterwards.

Pneumonia. The same is true of that dread disease pneumonia. The word itself frightens those who know most about the disease. They tell us that pneumonia kills more people each year than any other single disease except tuberculosis. It takes young and old alike. Here, as in consumption, the microbes multiply with extraordinary speed. And while they multiply they produce a poison which is deadly enough to kill the strongest man. The microbe of this disease gets into the air from the lungs of any one who has pneumonia. Those who have it must therefore stay in quarantine until they are well. At the same time, whatever comes from the mouth must be destroyed as carefully as if the disease were tuberculosis. Pneumonia usually starts when one has a cold, or is overtired, or has spent time in badly ventilated, crowded rooms. It also comes easily after some other disease that has left the body weakened. In order to escape pneumonia, then, and also to escape every other disease, the great line of defense is to keep the body in vigorous condition. The way to do this is to be faithful in following the general laws of health.

Pink Eye and Trachoma. In the schoolroom, however, even very healthy children may have pink eye or trachoma if they are careless about the microbes of these diseases.

The former is a nuisance; the latter is a very serious eye disease. Both afflictions often travel by the road of the public towel. If any child in a public school has a contagious eye trouble and uses the school towel, he will leave his eye-disease microbes on it. Later these same microbes will be left on the eyes of other children who use this towel. When an epidemic of eye disease is actually started, do not touch your hands to your eyes. Microbes may have been left on books, pencils, and desks by persons who have touched their diseased eyes with their hands. By handling the same things you may take the same disease unless you are strictly careful to keep your hands away from your eyes. All this restates facts given in Chapter XIX.

Disinfection and Antiseptics. We should also know that after any contagious disease, the room or the house should be thoroughly disinfected. This means that all the microbes of the special disease must be killed in order to save human beings from infection. The doctor or some other experienced person should attend to this matter, for the disinfection of a house is not the simple affair which some people imagine it to be. Unless it is thoroughly done, it is useless.

As a rule, antiseptics are used to destroy microbes on the body. A disinfectant is stronger and is used not on the body but on clothes, rugs, etc., where microbes must be killed.

In addition to all else, let us never forget that the health of the body demands two great things of us:

1. That we destroy disease microbes (tubercle bacilli, typhoid microbes, and all the others) before they have any chance to attack the body.

2. That we keep the defenses of the body in such vigorous condition that even if disease microbes enter, they will not conquer us, but will be conquered by us.

In other words, our war against the microbe means that we should do two things, and that we should do them both at the same time:

1. *Fortify the body.*
2. *Exterminate the foe.*

QUESTIONS

1. Mention some diseases which the modern army fights. 2. If everybody were careful, what would happen to our preventable diseases? 3. What danger was there in the skin the schoolboy distributed? 4. How long should the victim of an eruptive disease — measles, etc. — stay away from other people? 5. Describe the smallpox epidemic on Ponape. 6. What did smallpox do in Europe between 1700 and 1800? 7. What was Dr. Jenner's discovery in 1796? 8. What keeps us safe from smallpox nowadays? 9. Describe vaccination in New York City in 1901. 10. Why do epidemics spread fastest in crowded places? 11. Where in

the body does diphtheria start? **12.** In diphtheria, what must be done at once? **13.** Why is there haste? **14.** To whom is antitoxin given? Why? **15.** What was the former death rate from diphtheria? the death rate now? **16.** What should be done for a person who has been bitten by a mad dog? **17.** Why is delay dangerous? **18.** What epidemic swept Philadelphia in 1793?

19. What causes yellow fever? **20.** How may it be banished from the earth? **21.** To pass the disease on, what must the stegomyia mosquito first do? **22.** Name another disease carried by mosquitoes. **23.** Which mosquito carries malaria? **24.** How does the anopheles mosquito get the microbes which it carries? **25.** Why must we protect ourselves from the sting of the mosquito? **26.** What are cities doing in this line? **27.** Why do they pour kerosene oil over stagnant ponds? **28.** How do hookworms enter the body? **29.** Where in it do they start? **30.** How do they travel about? **31.** Describe their feeding; their size. **32.** Where do they lay eggs? **33.** Where do the eggs hatch? **34.** In what ways do people suffer from hookworms? **35.** When outside the body, where do they thrive best? **36.** Is hookworm disease more common in summer or in winter? **37.** In what regions is it most often found? **38.** What is ground-itch a sign of? **39.** What should be done with human waste to avoid spreading hookworm disease? **40.** Give medical commands to be obeyed wherever hookworms are found.

41. How do whooping cough and mumps reach us? **42.** What is said about knife, fork, spoon, etc.? **43.** Why is pneumonia such a serious disease? **44.** Whom does it attack, the young or the old? **45.** How fast do pneumonia microbes multiply? **46.** What do they produce? **47.** How do they get into the air? **48.** How should the patient protect the air from contamination? **49.** What is the great defense against pneumonia and every other disease? **50.** Which eye diseases may be caught in the schoolhouse? **51.** Why should we shun the public towel? **52.** How may we save ourselves from eye disease? **53.** Who should attend to the work of disinfection? **54.** What two great things does the health of the body demand of us?

CHAPTER XXIV

MAN'S FRIEND AND DEFENDER—THE PHAGOCYTE

Cholera Microbes and the Phagocyte. Scientists have known for a long time that the red blood corpuscle is the oxygen carrier of the body, but for years they came to no final conclusion about the occupation of his busy companion the white blood corpuscle, the phagocyte[1]—"the devourer," as his name means in Greek. The mystery vanished, however, when Professor Metchnikoff, of the Pasteur Institute, in Paris, turned his attention to the subject.

He took a healthy frog, carefully pricked some cholera microbes under its skin, and with his microscope watched the fate which befell them. The whole affair was easy to follow, for as soon as the cholera microbes entered the blood stream, white phagocytes flocked to the spot from all sides; they crowded close; each seemed to choose its special victim, and drawing closer yet, laid itself alongside its enemy, stretched itself into a new, curved shape, and little by little wrapped itself about the doomed microbe.

[1] All phagocytes are white blood corpuscles, but there are also white blood corpuscles that are not phagocytes.

How the Phagocyte captures Microbes. The phagocyte is really nothing more than a tiny round speck of living, active, independent substance called protoplasm, but it captures its victims relentlessly. In vain the microbes seemed to try to flee; their captors had surrounded them completely and held them firmly within their own bodies long enough to digest them. Instead of killing an enemy outright and throwing him aside, they rid themselves of him by swallowing him whole. Quickly hurrying to another, each phagocyte repeated the process, disposing of one microbe after another and growing larger with each captive.

SHAPES WHICH ONE PHAGOCYTE TOOK WITHIN A FEW SECONDS

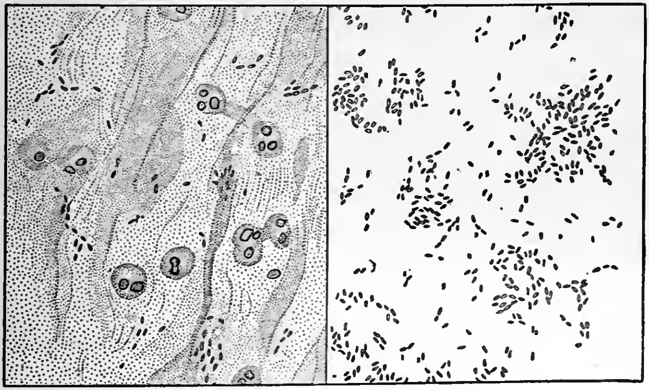
When the intruding microbes were small enough to make it possible, Professor Metchnikoff saw the phagocyte "swallow them in shoals as a whale swallows herring." Whereas if they were too large for one to manage alone, several phagocytes would surround the same microbe and digest him in partnership.

In this connection it is interesting to know that a frog never dies of cholera. The reason is clear — frog phagocytes are so vigorous that they conquer cholera microbes before the latter have a chance to manufacture their deadly toxin and give cholera to the frogs. In the same line of investigation Professor Metchnikoff next discovered that pigeons cannot be made to take tuberculosis, for here again, when he introduced tubercle bacilli into a pigeon's blood, the phagocytes seized them as fast as they entered the body and devoured them before any harm was done.

The work which the phagocyte does for the body is so valuable that we are easily tempted to talk about this free-swimming single cell as if it were a soldier fighting our battles. In point of fact, however, and even though they do behave like friend and foe, there would seem to be no real enmity between the phagocyte and the microbe.

How Phagocytes Travel. These small protectors of the body move from place to place in independent fashion. They spend most of their time in the blood, and in it they not only travel with the current but they also ignore the current entirely and, like the salmon, swim upstream as well as downstream, as occasion may require. At a moment's notice, also, they can leave the blood and pass through any bodily tissue without the slightest difficulty.

Vigorous and Feeble Phagocytes. Through Professor Metchnikoff's experiments, and others since then, facts have been learned which help human beings. If our phagocytes are strong enough to destroy disease microbes for us, we shall be saved from certain serious diseases. If, on the contrary, our phagocytes are feeble, or if microbes enter our body in such swarms that there are not phagocytes enough to fight them successfully, the enemy will be victorious, the phagocytes will be defeated, and we shall be the victims of any disease microbes that may attack us. Put two men



INFLUENZA MICROBES

On the left, as they are found in the sputum of some colds; on the right, as they are raised in the laboratory

into a town where cholera is working havoc; let one have more vigorous phagocytes than the other, and he will be the one more likely to escape with his life. Let measles or pink eye, whooping cough or influenza, break out in school, and those children with the most numerous and active phagocytes will suffer the least. Let tubercle bacilli be thick in the dust we breathe, and those of us who own the best bodyguard of well-developed phagocytes will be least likely to take the disease and to suffer from tuberculosis afterwards.

The same law holds true even for less serious illness. When some one says, "I am so sensitive, I catch cold at the least exposure," it is quite as if he said, "My phagocytes are wonderfully weak and inefficient; they are vanquished by all the microbes of influenza that enter my body." Another person says, "I never seem to take cold," and it is as if he said, "My phagocytes are such valiant warriors that they destroy every intruding microbe."

The Phagocyte as a Scavenger. Yet the phagocyte is not merely an athletic policeman and a valiant soldier; he is also a scavenger and a street cleaner that never seems to be idle. Here and there through the body he hurries, always trying to remove waste matter and to destroy intruding microbes.

You cut your hand, or you run a sliver into your finger, and from every side phagocytes hasten to clear away the rubbish and to attack the microbes. If they can kill these mischief-makers as fast as they drift in, the wound will heal quickly; if, instead, the phagocyte is too weak to slay the enemy, there will be a painful sore, slow to heal. Hospitals are full of patients who prove this difference in their own bodies. One man has a wound that heals at once, and he goes home happy; another man stays in the hospital for weeks, waiting for his wound to heal. The difference in the time of recovery rests with the phagocytes of the two men.

What Pus Is. Matter, or pus, from a wound is the host of microbes and phagocytes that have been slain in the struggle. They are being washed away by fluids from the wound. It has been estimated that in one ounce of pus there may be as many as 150,000,000 phagocytes who died fighting.

The warfare within our bodies is a silent one; we hear no sound of any conflict. Nevertheless, throughout our lives the strife goes on ceaselessly, and it makes all the difference between life and death to us whether or not our standing army of phagocytes is in good fighting trim.

In view of this fact our daily command to ourselves should be: *Protect the phagocytes from harm.* Many laws of health are, indeed, so truly laws for their protection that he who follows these laws most strictly will at the same time be doing the most for his bodyguard.

Cholera Epidemic and Alcohol. In Glasgow, in 1848, a little more knowledge might have saved hundreds of lives. A great cholera epidemic swept through the city, and it attracted so much attention that Dr. Adams studied it for the sake of telling people how to protect themselves. He kept a keen eye on the death rate of his cholera patients and discovered that those who went without alcohol had a vastly better chance of recovery than those who used it. Or, to put the facts more exactly, when those who used alcohol caught the disease, ninety-one out of every hundred died; whereas, when those who did not use alcohol had the cholera, only nineteen out of every hundred died.

Knowing what we do about the effect of alcohol on living tissue, and knowing also about the discoveries which Professor Metchnikoff made in connection with cholera microbes and phagocytes, we understand at once why that condition of affairs existed in Glasgow. The men and women who did not use alcohol owned phagocytes that were vigorous enough to conquer the attacking cholera microbes; the men and women who used alcohol had weakened their phagocytes to such an extent that when invading enemies came they were not strong enough to slay them.

Dr. Delearde had two cases which illustrate precisely this point.

Hydrophobia and Alcohol. A man and a boy were bitten on the same day by the same mad dog. The boy, thirteen years old, was bitten on the head and face, which are the very worst places for such wounds. The man was bitten on the hand alone — a much less serious matter. Both victims were taken to Dr. Delearde, and he gave each his most careful treatment; but the man, who should have recovered, died of hydrophobia, and the boy, who might have been expected to die, recovered. The only difference in the two cases seemed to be that the man used alcohol and the boy did not.

Alcohol and the Phagocyte. This led Dr. Delearde to make experiments to determine whether or not alcohol had any effect on the phagocytes. He took two sets of rabbits; to one set he gave a little alcohol each day; the other set received no alcohol. He then vaccinated both sets as a protection against hydrophobia. After they were supposed to be proof against the disease, he put the poison of hydrophobia into their blood, and the experiment gave the result he had expected. The rabbits that had had alcohol took the disease as easily as if they had not been protected against it, whereas the poison had no effect whatever on the rabbits that had not had alcohol. They did not take hydrophobia. Evidently their phagocytes had served them well.

In looking back to the seventeenth chapter of *Health and Safety*, we now understand one reason why Bum and Tipsy suffered so much more than Nig and Topsy when the epidemic of dog illness raged in Worcester. Alcohol had weakened their phagocytes to such an extent that disease microbes had the upper hand from the start.

Just here it is necessary to call attention to an important fact. When death comes from disease microbes, it is not the microbe itself but the poison which the microbe gives off while it multiplies that does the mischief. Each disease microbe has its own special variety of poison (toxin), and fevers of one sort or another simply show that a fierce fight is going on between microbes that are producing poison and phagocytes that are devouring the poison producers.

Over and over again, in many microbe diseases, death comes from the fact that the body is poisoned by the toxin which the microbes have produced.

Phagocytes that Multiply for Emergencies. This is particularly true in that dread disease, pneumonia, and sometimes a doctor helps science by following the record of the battle. From time to time he draws a drop of blood from the arm of his patient and examines it under the microscope for phagocytes. He knows that the sufferer's chance of life increases or decreases with the number of these protectors. The normal count is from 5000 to 7000 phagocytes in each cubic millimeter, and it takes 50 cubic millimeters to make one drop of water.

When, by his examination of the blood, the doctor finds that the number of phagocytes is mounting steadily upward from 10,000 to 20,000, from 20,000 to 50,000, and even to 70,000, he takes courage. He knows that "the body is rallying its forces to battle with the invading hosts of microbes, and that if the fight can be kept up long enough, the victory will be won."

Scientists say that phagocytes are being manufactured constantly in certain lymph tissues, and that when a special need comes, when a wound is made in the flesh or when disease microbes multiply in the blood, then the tissues send out new regiments of phagocyte soldiers by the thousand and the million. And it seems that even the youngest of these soldiers is ready for immediate service.

The Conqueror of the Phagocyte. Nevertheless, although a young and healthy phagocyte may be so vigorous as to be like a Samson among his microbe enemies, still, as we have seen already, there is a way to defeat and destroy him. Let one of these young phagocytes be launched into blood that has alcohol in it, and what is the result? Does he gain courage for the fray? Does he hurry off to the battle ground with the greater strength?

Quite the contrary; his fate is now sealed, for the alcohol overcomes him with a subtle power more deadly than that of any microbe. It is a poison which will dull a phagocyte or paralyze him utterly, according as there is more or less of it in the blood.

A trace of alcohol does not rob phagocytes of all power. They may still be strong enough to reach the scene of battle; they may even contend with a microbe on the way there; but instead of being strong enough to conquer, they are now weak enough to be conquered. When such a condition exists, disease microbes find themselves free to carry on their business of toxin manufacture without interruption.

From beer and hard cider all the way through to gin and brandy, every drink containing alcohol harms the phagocyte, and the more alcohol the drink holds the more is the phagocyte damaged by it. The following table shows what per cent of alcohol is found in various drinks that are in common use:

PERCENTAGE OF ALCOHOL IN COMMON DRINKS

Beer	3–5
Hard cider	4–5
Ale	7–8
Wines of different kinds	7–20
Champagnes	11–18
Brandy	30–55
Whisky	50

The Man who Drinks. In view of this power of alcohol, we realize that when a man raises his glass cheerfully to his lips and drinks to the health of his king or his friend, he drinks in truth to the success of disease microbes in his own body, while at the same time he drinks to the death of his own most faithful bodyguard.

If the owner of a castle had drugged his watchmen on the towers, had bound his soldiers hand and foot, and had killed his bodyguard, would he have the right to be surprised when he found his worst enemy within the gates? If that enemy robbed him, or beat him cruelly, or killed him by slow torture, would any one be to blame but the owner of the castle himself?

Protect your phagocytes from harm by observing the laws of health, and they will protect you in time of need. Weaken them through the use of alcohol or any other poison, or through neglect of the laws of health, and you will be as a man who has drugged his watchmen on the towers, bound his soldiers hand and foot, and killed his bodyguard. He who has done all this is sure to suffer when the enemy comes.

QUESTIONS

1. What is the phagocyte? **2.** What does its name mean? **3.** Describe the experiment with the frog and the cholera microbes. **4.** How do phagocytes capture and destroy microbes? **5.** Why does a frog never die of cholera? **6.** Why do pigeons never have tuberculosis? **7.** Describe the action of phagocytes in the body. **8.** If intruding disease microbes are more numerous or more vigorous than our phagocytes, what happens to us? **9.** If a person yields quickly to a disease, what does this prove about his phagocytes? **10.** If he is able to resist disease, what is it that has saved him? **11.** What does the phagocyte do in case we are cut or wounded? **12.** What is pus? **13.** What difference may there be in the healing of the wounds of two men in a hospital?

14. What should be our daily command about phagocytes? **15.** What connection is there between the laws of health and the vigor of the phagocyte? **16.** What was noticed during the cholera epidemic in Glasgow in 1848? **17.** How do you explain the connection between the death rate and the drinking of alcohol? **18.** Tell about the boy and the man who were bitten by the mad dog. **19.** What experiments did

Dr. Delearde make on the rabbits? **20.** How did he explain the results? **21.** Why did Bum and Tipsy suffer more from disease than Nig and Topsy? **22.** Which does the most harm in the body, disease microbes themselves or the toxin they produce? **23.** In a case of pneumonia, why does the doctor take courage when phagocytes increase their numbers? **24.** Where does he look for the phagocytes? **25.** What occurs when a phagocyte finds itself in blood that holds a trace of alcohol? **26.** When phagocytes are overcome by alcohol, what is the outlook for disease microbes in that body? **27.** When a man drinks to the health of his friend, to whose success and to whose death is he really drinking? **28.** Why should we protect the phagocytes from harm?

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GLOSSARY

KEY TO PRONUNCIATION

a as in fāte, senȧte, făt, ärm, a̤ll, ȧsk, whạt, câre.
e " mēte, ėvent, mĕt, hẽr, thêre, the̱y.
ee " fe̅e̅t.
i " īce, ĭdea, ĭt, sĩr, machïne.
o " ōld, ȯbey, nŏt, mo̤ve, wọlf, sȯn, hôrse, wõrk.
oo " fo͞od, fo͝ot.
u " ūse, ụnite, ŭp, fûr, rṳle, pu̇ll.
y " flȳ, mẏself, babў, mỹrrh.
au " author.

aw " saw.	ew	as in new.	oi	as in boil.
oy " boy.	ou	" out.	ow	" cow.
c (unmarked) as in call;	ç	" mice.	ci (=sh)	" gracious.
ch (unmarked) " child;	ch	" chaise;	ch (=k)	" school.
g (unmarked) " go;	ġ (=j)	" cage.		
ng as in ring.	n̲ (=ng)	" ink.	ph (=f)	as in phantom.
ş (=z) " is.	si (=sh)	" tension;	şi (=zh)	" vision.
th (unmarked) as in thin;	th	" then.	ti (=sh)	" motion.
x (unmarked) " vex;	x̣ (=gz)	" exact.		

Obscure sounds: a̬, e̬, i̬, etc. Silent letters are italicized.

ăb dō′mĕn, the part of the body below the diaphragm.

ăd′e̬ noid, a growth of tissue in the back of the nose.

a̬ dŭl′tẽr āt*e*, to make impure.

ăl ĭ mĕn′ta̬ rў canal, the food canal.

ăn ŏph′e̬ lēş, a species of mosquitoes that carry malaria.

ăn tĭ sĕp′tĭc, anything which destroys the microörganisms of disease.

ăn tĭ tŏx′ĭn, a substance which neutralizes the action of a toxin or poison.

ăn′vĭl, one of the small bones of the ear.

ā ôr′ta̬, the great artery from the heart.

ā′pĕx, the top or summit of anything.

ā′quė *o*u̬s hū′mo̬r, the liquid between the crystalline lens and the corona of the eye.

ăr′chĭ tĕct, one who plans buildings.
ăr tē′rĭ al, pertaining to the arteries.
ăr′tēr ў̆, one of the vessels or tubes which carry the blood from the heart.
as tĭg′ma tĭşm, a defect in the refractive apparatus of the eye.
ăt′rō phў̆, a wasting away from lack of nourishment.
au′dĭ tō rў̆, pertaining to the outer and inner passages of the ear.
au′rĭ cle, a division of the heart receiving blood from the body.
au′tō-ĭn tŏx ĭ cā′tion, poisoning of the body by toxins formed within the body.
ăx′ŏn, a fiber from the cell body.

bȧ çĭl′lŭs, a microbe which is the cause of various diseases.
băc tē′rĭ a, forms of microbes.
bĕv′ēr ăġe, drink of any kind.
bī′çĕps, a muscle having two heads; the term is applied to a muscle in the arm.
bīle, a yellow, bitter fluid, secreted by the liver.
biş′mŭth subnitrate, a chemical.
brŏn′chĭ al, belonging to the tubes or air passages of the lungs.
brŏn′chĭ ōle, a small bronchial tube.

căf′fē ĭne, an alkaloid found in coffee.
căp′ĭl lā rў̆, one of the tubes connecting arteries and veins.
căr′bō hȳ′drāte, a chemical term.
căr′bŏn dī ŏx′īde, carbonic acid; a gas.
căr′dĭ ăc, pertaining to the heart.
căr′tĭ lăġe, an elastic tissue; gristle.
cĕl′lū lōse, the inclosing membrane of plant cells.
çĕr ē bĕl′lŭm, a division of the brain situated at the back of the head below the cerebrum.
çĕr′ē brŭm, the upper and larger division of the brain.
chŏl′ēr a, an infectious and often fatal disease of the digestive organs.
chȳle, the contents of the small intestine.
chȳme, food in the form in which it passes out of the stomach.
çĭl′ĭ a, minute hairlike growths from a cell or other part or organ of the body.
çīr cū lā′tion, motion in a circle or circuit.
çīr′cū lȧ tō rў̆, pertaining to circulation, as of the blood.
cō ăg ū lā′tion, the act of changing from a fluid to a thickened state.
cō′ca ĭne, a drug which produces local insensibility.
coch′lē a, a part of the inner ear in most vertebrate animals.

cŏn'cāve, curved in.

cŏn trăc'tion, a shrinking; shortening.

côr'nē a, the hard transparent front portion of the eyeball.

côr'pŭs *cle*, a minute particle; blood corpuscles — the blood disks or cells.

côr'tĕx, the layer of gray matter covering the surface of the brain.

crude, raw, not fitted for use by any artificial process.

crys'tăl *lĭne* lens, a lens of high refracting power behind the iris of the eye.

cū'lĕx, the common, harmless mosquito.

cûr'vȧ tūre, a bend; a curve.

Czär'e vĭ*tch*, the title applied to the eldest son of the emperor of Russia.

dĕn'drīte, a crooked fiber from the cell body.

dẽr'mĭs, the second layer of skin.

dī'ȧ phră*g*m, a muscle separating the chest from the abdomen.

dĭph thē'rĭ ȧ, a disease of the throat.

dĭs ĭn fĕc'tion, destruction of the germs of contagious diseases.

ĕp ĭ dĕm'ĭc, a disease attacking many persons at the same time.

ĕp ĭ dẽr'mĭs, the outer layer of skin.

ĕp ĭ glŏt'*t*ĭs, a valvelike organ which keeps food and drink from getting into the larynx.

ē rŭp'tĭv*e* disease, a type of disease affecting the skin.

ĕr ȳ sĭp'ē las, a disease characterized by an inflammation of the skin and accompanied by fever.

*E*ū stā'chĭ an tube, a tube leading from the middle ear to the pharynx.

ĕx pĕc'tō rāt*e*, to spit.

ĕx tĕn'sor, a muscle which extends or straightens any part of the body.

flĕx'or, a muscle which bends any part of the body.

găn'glĭ ŏn (plural, ganglia), a collection of nerve cells.

găs'trĭc juice, a fluid secreted by the stomach.

ġĕl'ȧ tĭn, a substance made by boiling bones and other tissues.

ġẽrm, microbe.

glănd, a secretory part or organ, which secretes a substance peculiar to itself.

glŏb'ūl*e*, a little globe.

glŏt'*t*ĭs, the mouth of the windpipe.

glȳ'cō ġĕn, a substance found in many animal tissues and especially abundant in the liver.

goi'tẽr, enlargement of the thyroid gland on the front and sides of the neck.

grăn'ūle, a little grain, a fine particle.

ġy̆m'nȧst, one skilled in athletic exercises.

hăm'mẽr, one of the small bones of the middle ear, named from its shape.

hī'bẽr nāte, to pass the winter in a torpid state, as some animals do.

hȳ drŏ chlō'rĭc acid, an acid formed by the union of chlorine and hydrogen.

hȳ drŏ phō'bĭ a̱, a disease caused by the bite of a mad dog.

ĭn flṳ ĕn'za̱, an epidemic catarrh.

ĭn grē'dĭ e̱nt, one of the elements of a combination, as a drink or medicine.

ĭn ŏc'ū lāte, to introduce germs into the tissues for protection.

ĭn tẽr cŏs'ta̱l, between the ribs.

ĭn tĕs'tĭne, the lower part of the alimentary canal.

ī'rĭs, the colored curtain of the eye, seen in the front of the eyeball.

lăb'y̆ rĭnth, part of the inner ear.

lăch'ry̆ ma̱l gland, a gland which secretes tears.

lăr'y̆nx, the part of the windpipe in which vocal sound is made.

lăt'ẽr a̱l, sidewise.

lēague, persons united for some particular purpose.

lĭg'a̱ me̱nt, the tissue that connects bones.

ly̆mph, a colorless fluid found in animal bodies.

ly̆m phăt'ĭc, a vessel which conveys lymph.

măr'rōw, a soft tissue found in the interior of the bones.

mēa'ṣleṣ, an eruptive contagious disease.

mĕm'brāne, a thin soft tissue in the form of a sheet or layer covering parts of the body.

mĕn'ū, a bill of fare.

mī'crōbe, a creature so small that it can be seen only through a microscope.

Mī crō nē'sĭa̱, a collection of islands and groups of islands in the Pacific Ocean.

mī'crŏ scōpe, an instrument for examining objects too small to be seen by the naked eye.

mū'cu̱s, a thick fluid secreted by the mucous membrane of animals.

mŭs'cle, a tissue the contraction of which causes motion.

mŭs'cū la̱r, having well-developed muscles; strong.

năr cŏt'ĭc, a substance having the power to produce stupor.

neū'rŏn, a nerve cell.

nĭc'ō tĭne, a highly poisonous substance obtained from tobacco.

nī trŏg'ē nous, pertaining to nitrogen.

nôr'mal, regular; natural.

nū'clē us, the vital center of a cell.

nū trĭ'tion, that which nourishes or repairs the waste in tissues.

œsophagus (ē sŏf'a gŭs), the tube through which food and drink are carried to the stomach.

ŏl făc'tō rȳ nerve, the nerve connected with the sense of smell.

ō'pĭ ŭm, the dried juice of the poppy; a drug.

ŏp'tĭc nerve, the nerve connected with the sense of sight.

ôr'găn'ĭc, pertaining to objects that have organs; hence pertaining to the animal and vegetable worlds.

ŏs mō'sĭs, the diffusion of fluids through animal membranes.

ŏx ĭ dā'tion, the process of combining with oxygen.

ŏx'ȳ ġen, the element of the air that supports animal life.

păl'āte, the roof of the mouth and floor of the nose.

păn'crē ăs, a gland near the stomach which secretes a fluid having important uses in digestion.

păn crē ăt'ĭc fluid, a clear liquid secreted by the pancreas.

păr'a lȳze, to render helpless.

Păs'teûr Institute, a place where Pasteur's method of treating certain diseases is practiced.

păt'ent mĕd'ĭ çĭne, a ready-made medicine, sometimes patented.

pĕr ĭ ŏs'tē um, a fibrous membrane covering the surface of bones.

pĕr ĭ stăl'tĭc, contracting in successive circles.

phăg'ō çȳte, a white blood corpuscle.

phăr'ȳnx, the part of the food canal between the mouth and the œsophagus.

pĭg'ment, coloring matter.

plăș'ma, the liquid part of the blood.

pleū'ra, the membrane which lines the walls of the chest.

pleū'rĭ sȳ, inflammation of the pleura.

plĕx'us, a network of nerves.

pneū mō'nĭ a, inflammation of the tissues of the lungs.

Pō'nä pe, one of the Caroline Islands.

prō'tē ĭd, a substance from which living tissue is formed.

prō'tō plăşm, a substance constituting the basis of life of all plants and animals.

*p*tō mā'ĭn*e*, a substance formed from animal or vegetable tissues during putrefaction.

pŭl'mō nā rȳ, pertaining to the lungs.

pŭls*e*, the beating of the heart as felt in the arteries.

pŭs, an inflammatory liquid issuing from abscesses or sores.

pȳ lŏr'ĭc, pertaining to the pylorus.

pȳ'lō'ru̯s, the opening through which the contents of the stomach pass into the intestine.

rĕġ ĭ mĕn'ta̯ls, military clothing.

r*h*ȳth'mĭc, occurring at regular intervals, like accents in poetry or music.

rĭ*c*k'ĕts, a disease of children, in which they are weak in the joints.

rō'tāt*e*, to revolve; to move round a center.

săl ĭ çȳl'ĭc, the name of an acid.

sa̯ lī'va̯, a digestive fluid secreted by glands in the mouth.

săl'ĭ vā rȳ, pertaining to saliva.

săn ĭ tā'tiōn, putting and keeping anything in healthy condition.

săr cō lĕm'mȧ, the covering of separate muscle fibers.

sclē rŏt'ĭc coat, part of the eyeball.

sew'aġ*e*, the matter which passes through sewers.

skĕl'ē ta̯l, pertaining to a skeleton.

sphȳg'mō grȧph, an instrument used in determining the strength of the heart beat.

spū'tŭm, that which is spit or raised from the lungs.

stĕg ō mȳ'ĭ ȧ, a mosquito that carries yellow fever.

stĭm'ū la̯nt, that which excites.

stĭr'*r*u̯p, one of the three bones of the middle ear.

stŏm'a̯ch, part of the digestive apparatus.

sȳ*m* mĕt'rĭc a̯l, well proportioned in its parts.

sȳ nō'vĭ a̯l fluid, secreted in the joints.

sȳr'ĭnġ*e*, an instrument like a pump, for drawing in and ejecting liquids.

sȳs tĕm'ĭc, pertaining to the body as a whole.

tăd'pōl*e*, the young of a frog.

tĕn'dōn, a bundle of fibers which joins a muscle to a bone.

tĕns*e*'lȳ, tightly; rigidly,

thē'ĭn*e*, a substance found in tea.

thē ō brō'mĭn*e*, an alkaloid substance found in chocolate and in cocoa.

thō răç'ĭc, pertaining to the thorax, or chest.

thȳ'roid, a gland in the neck.

tŏn'sĭl, one of two oval bodies on each side of the opening of the throat.

tŏx'ĭn, a poison produced in the body.

trā'chē a, the windpipe, beginning at the larynx and ending at the bronchial tubes.

tra chō'ma, a disease of the eyes.

tū bẽr cle, a small mass of diseased matter.

tū bẽr cū lō'sĭs, a disease caused by the tubercle bacillus.

tȳ'phoid, a disease caused by contaminated food or drink.

tȳ'phus, a kind of fever.

văc çĭ nā'tiȯn, inoculation with vaccine to prevent smallpox.

vā'pôr īze, to convert a liquid into vapor.

vein, a vessel which receives blood from the capillaries and returns it to the heart.

vē'nous, pertaining to the veins.

vĕn'trĭ cle, a division of the heart receiving blood from the auricle.

vẽr'tē bra, one of the small bones which make up the spine.

vĭl'lŭs (plural, vĭl'lī), a minute elevation on the lining of the small intestine.

vĭt'rē ous hū'mor, the transparent jelly which fills the back part of the eyeball.

vŏl'a tĭl īze, to cause to evaporate.

FOREIGN NAMES

Aschaffenburg (ȧ shȧ'fen bo͞ork)
De bōve'
De le ärde'
Fāi șȧns'
Flourens (flo͞o răns')
*H*ō tĕl de Vĭlle'
Krāe'pe lĭn
Mĕr'nĕtsch
Mĕtch'nĭ kŏff
Pavlov (päv'lôf)
Trēves

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