YOURSELF AND YOUR BODY

WILFRED THOMASON GRENFELL, M.D.

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FOREWORD

No one, better than the author, realizes the psychological liberty taken in this book. Even the temporary assumption that an Ego exists and has headquarters in a material body is, I am told, a menace to progressive scientific thinking; while even to "make believe" that an Ego controls the reactions of life through pyramidal cells, as press buttons, is a serious venture.

I am told that mind does not occupy space and that I have no right to assume relationship between cell masses and mental phenomena, or molecular movements and the energy called "emotions."

On the other hand, it seems to me that there is something about the phenomena of human life that would lead one—or lead it—or lead something—to suppose "we," or it, or something, are not energy; but that "we" use energy. What seems to me more correct is that some part of something that isn't subliminal uses energy—and that something persists above and beyond the line, as well as below it. Whether the proton and electron are something moving around, or nothing moving around, seems a serious question. Indeed

"Is anything anything?" seems a question to-day rather for the theologian and metaphysician than the chemist and physicist. This is a day of increasing faith in current science that is far ahead of the stuffy cocksureness of half a century ago.

This book is a venture. But the objective seems to have justified the method without committing one to any general hypothesis that an end justifies a means.

WILFRED T. GRENFELL.

PREFACE

Nothing on earth is so valuable to a man as a sound body. The old Romans held that in a sound body dwelt a sound mind. We can go further and admit that the actions of a soul itself are influenced by the health of the body, for it is only the soul's machine, and it is the soul's only machine on this planet. More sins are the result of defects in our physical machine than we can realize.

The jelly, or protoplasm, out of which it is made becomes granular or fibrous when it should be clear or elastic, and then, like a steel axle that has gone granular, we tell it, as usual, to do one thing and it does another. Very ordinary habits, like the pleasure of a good meal, grow on us till they become a physical sin, just as the habit of drinking whisky is acquired very easily. Henry I of England lost his life by overindulgence in eating fish called lampreys. This kind of suicide is just as bad as any other kind, and is a sin against life itself. Punishment and disgrace are the inevitable result of all physical sins.

Having two sons who had just reached the age of ten million Whys? and Hows? and Whens?

and Wheres? it occurred to me that they would respect the development of their bodies more if they understood more about them; and that they certainly should be as much interested in the perfection of their bodies as in that of their studies of birds or collections of postage-stamps. Man naturally prizes what he knows to be of personal value to himself, and will not willingly allow it to come to harm. We still know little enough about how to perfect our bodies. But the recent discoveries of the enzymes, endocrines, the vitamines, the hormones, and many other agencies which influence bodily development, or at least protect it from a thousand dangers as do sera, vaccines, antigens, and so forth, make us increasingly realize how much more we can do to add a cubit to our stature and years to our time on earth than once we dreamed of.

As we begin to know what infinitely marvellous conglomerations our bodies are—combining every kind of machine on earth into one, and then outclassing every one of them—we also begin to know how easily they can be irretrievably spoiled. Moreover, when we find that the most wonderful regulations of the body and its functions are so essentially material that even its subtlest governing factors, like adrenalin, can be made out of ordinary coal tar, or, like thyroidin, out of seaweed, we realize more our responsibility and opportunity for its rational care.

The wise Greek adage, *γνῶθι σέαυτον* (know thyself), can and should be made now to include at least a bowing acquaintance with so individual a personal possession as our bodies. How many people discover all too late that their bodies have been irremediably injured through their own ignorance. Alas, innocence does not save from the inevitable retribution of physical sin. If the greatest Christian saint puts his finger in the flame of the candle it will be burned exactly like that of an every-day sinner. If you *will* put very hot things in your mouth and swallow them to save the pain of burning your tongue, you will get an ulcer in your stomach whether you are an aged multi-millionaire or an impetuous " sans culotte."

Most of the pictures are, obviously, original; though, of course, some are drawn from well-known works on physiology or anatomy, such as Gray's, Starling's, and others. I trust the authors will forgive any liberty this has involved. But for their splendid labours, no one would know anything of these most wonderful works of God.

I beg to acknowledge the kindness of my friend, Dr. H. Letheby Tidy, who read the book for me prior to the British edition.

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CHAPTER I

LIVING MACHINERY

Or How the Parts of our Bodies are Put Together, What They are Made Of, and How They Work

In our family, a wandering life separates us much from the children, but at last a holiday together, on the beautiful shores of Lake Champlain, offered us the chance we needed.

"How would you like a talk about how we see, and hear, and smell, and move, and think, and eat, and breathe?" I volunteered one day.

The spontaneity of the reply left no room for doubt about their approval, and so I continued:

"This is far the most wonderful story in the world. Marvellous things are built by men, but this is more wonderful than a fairy palace, for every brick is alive, and the parts make themselves. It is the only real automatic machinery in the world. Moreover, the units make their own rules; choose some to govern the rest, while they train others to do all the repairing, feeding, draining, tending the pumps, and manufacturing of everything needed from a drain-pipe to a seeing-machine. They do all their own cleaning. They keep their own police and maintain armies to protect the whole machine. There is nothing they do not do.

"'Before we can understand even a little about it, however, we shall have to know a bit about almost everything. First we must be clever scouts, so as to be able to guess rightly the real reason for each piece and each contrivance. Any one can pull a machine to pieces, but it takes a very wise head to build it up. So we must be philosophers, mechanics, opticians, chemists.

"First, there is anatomy. It shows us how blood pumps are made, how the frame is built up, how the wires and central office are placed, how one part of the machinery is fitted to the next, how the fuel is turned into power, how the drains are arranged for, and how the whole lot of live things makes one great big living giant machine, which can see to walk about, scent danger, test the fuel as it goes in, know things by the feel of them, memorize facts, and become what we call a 'living man.' We must also know how the machinery gives, receives, and acts on intelligent orders.

"Besides all this we want to know what each part is built up of and how it does its work, and how the various parts work together, like the transportation system, the supply system, and the system for dealing with garbage. All these and many more are together called physiology.

" In order to know how we see we must know what light is; how we hear, what sound is; how orders travel, the way in which electricity works. These kinds of things are called physics.

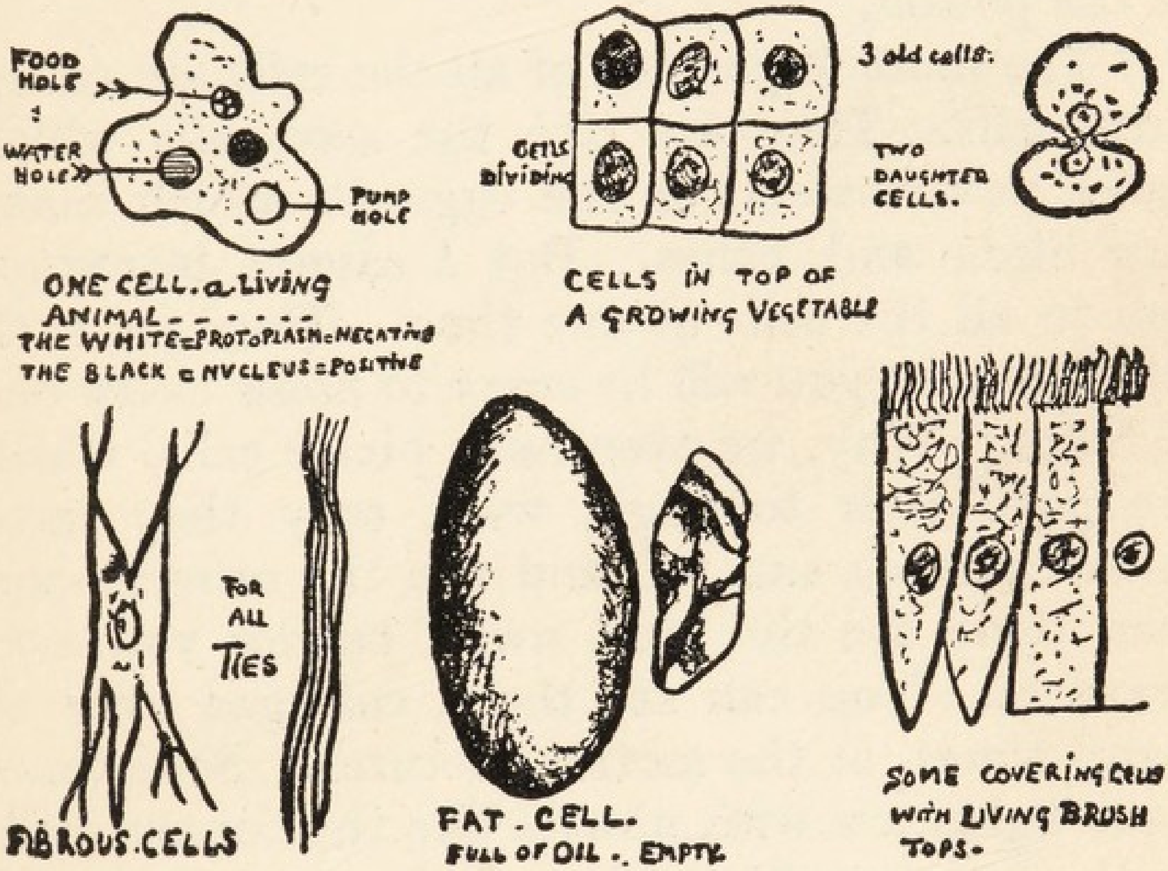
" We must learn how the machine turns fluids solid, and solids fluid : that is, how acids work, what alkalies are, and how ferment-cells act—that is, how yeast makes flour into bread, and how in the same way our machine makes it back into flesh and bones and blood. That is chemistry. You will love that. It is intensely interesting.

" However, even such fine machines as go together to make up what we call our bodies do at last get out of repair and old, and then they have a 'break-down,' like the engine of the motor-car. So we must learn to know what has gone wrong. This is called pathology.

" The bricks from which we build the body are called cells. One cell is too small a thing even to see, without a microscope. But they are really more than ordinary bricks. They are like the things in 'Alice in Wonderland.' They do the building themselves, and they also pull it down and repair it themselves. We doctors do not heal people's bodies. All we ever do is to give these marvellous fairy bricks fair play.

" The cells get together into groups just like manufacturing companies; and they are the wisest companies ever formed—small as they are. One lot enables us to have thoughts. The brain is our thought factory, and also our general headquarters, with the generals, staff officers, and orderlies. It is the seat of government, of the general telegraph, of the telephone, and is a wireless projector as well as receiver. This machine is the smallest machinery for carrying on so much work that ever existed. In one way, also, it is rather like the Standard Oil Company. It has all the other companies associated with it, but it directs them all. Each company has to do a whole lot of jobs—just as many as ever it can, in order to save office and factory space.

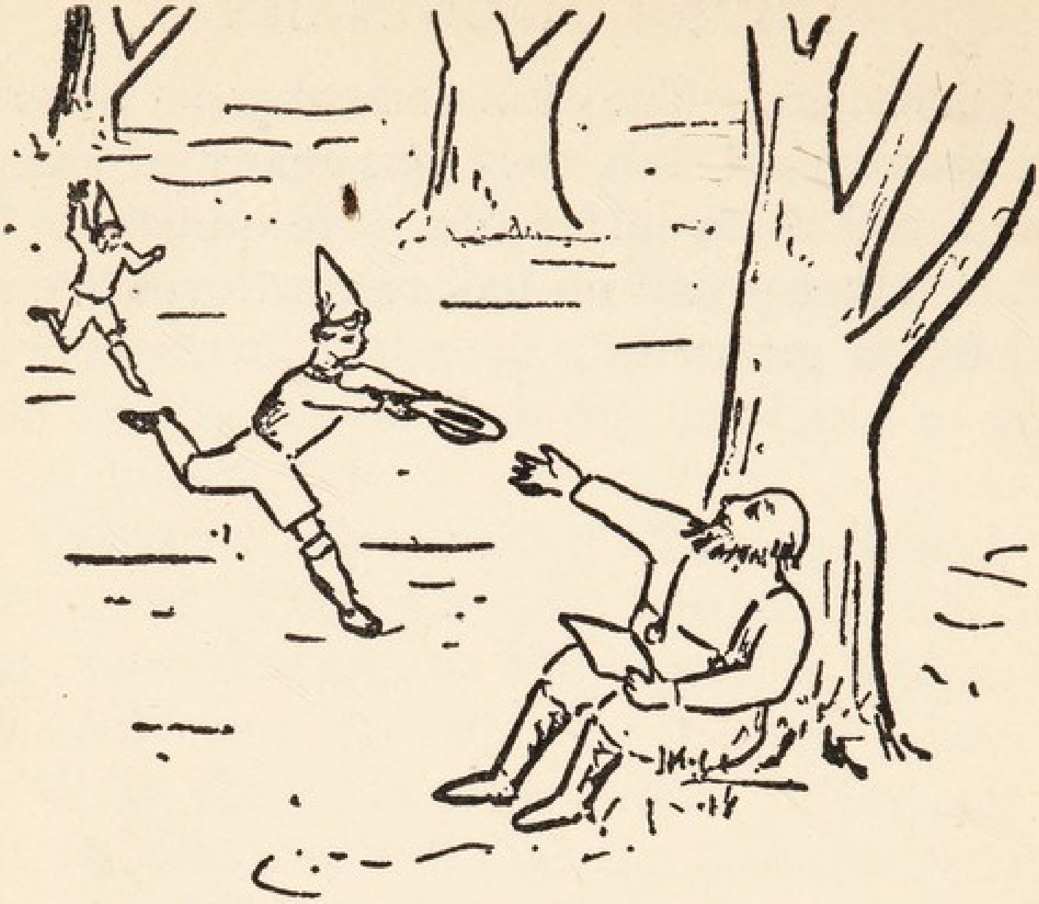
"The cells unite for every sort of work: to make glass like the front of the eye, or strings to catch sounds as in the ear, or taste-buds to warn us of dangerous things in our mouths which we must not swallow, or, on the other hand, to help us enjoy good food, or to digest what we eat, as the stomach, liver, and pancreas cells do. Some cells unite to tie things together, like ligaments, or to keep them from bumping, like elastic tissue buffers. (Picture 1.) Some cells, like coral animals, build the framework up such as bone, and others form the engines to move it about, like muscle-cells; some build the pipes for circulating streams; some keep those pipes clean; some carry oxygen down the pipes to burn up and give the machine its horse-power; some carry food down the pipes, others bring materials for building. Some are policemen who catch burglars or fight enemies, as soldiers do. Some build the skin as a rampart to protect the outside and keep it in repair; others cover it with hair to keep it



1. A few cells.

warm. Others again make our nails so that we can pick things up, like the machines in a watch factory, which have metal fingers for collecting the parts. Others make soft, warm, smooth coverings for all the inside things, and others, still, are just greasers, who oil the joints and keep soft the linings of all the hollow parts of the machinery such as the food-tubes or intestines, or the inside of the mouth and nose. Some have to wash the eyes all day and keep them moist and soft. No task is too big or too small. Cells are never ashamed to do anything useful. Some, therefore, just make all the refuse of the body smell bad so as to warn the machine to get rid of the poison.

"The most important of all the cells are called germ-cells. They are like the seed-cells which make new flowers, or the egg-cells which make new birds and fishes. But I cannot introduce you to all the cells at one time. They are such wonders that you will be crazy to know every one of them. Why, we even have pirate cells, which are good cells to begin with, only they have turned pirates and kill and rob the others—and then there are the most awful battles you ever heard of. You can see them, enlarged ever so many times, in the motion-pictures. Sometimes these fights are with pirates like the tumour-cells or the cancer-cells, and sometimes with regular invading armies called spirochætes, like dragons or snakes. You will surely want to see the brave White cells fighting to the death, and never sparing themselves, gladly dying to save the others. They never seem to need calling twice. There is one special lot that only sprinkles poison, like the poison-gas brigade, to kill the enemy; and one White regiment which does nothing but carry away the dead and clean up the battle-field when it is over. The Whites take lots of prisoners. They kill and eat most prisoners to be economical, but they put many of them in jail and wall them in for life. No quarter is ever given or taken—and no bail or reprieves are ever asked for or granted."



2. " Give me my hat."

CHAPTER II

THE CLASS

" Let us draw pictures as we go along, shall we? The first thing that I want you to remember is that my body is mine, but it isn't I."

" Oh, father!"

" However, we cannot draw without something to draw with, can we?"

That wanted thinking about. Boys do not like to be tricked.

" No? Well, then, you go and get something. This is my paper and my pencil, isn't it?"

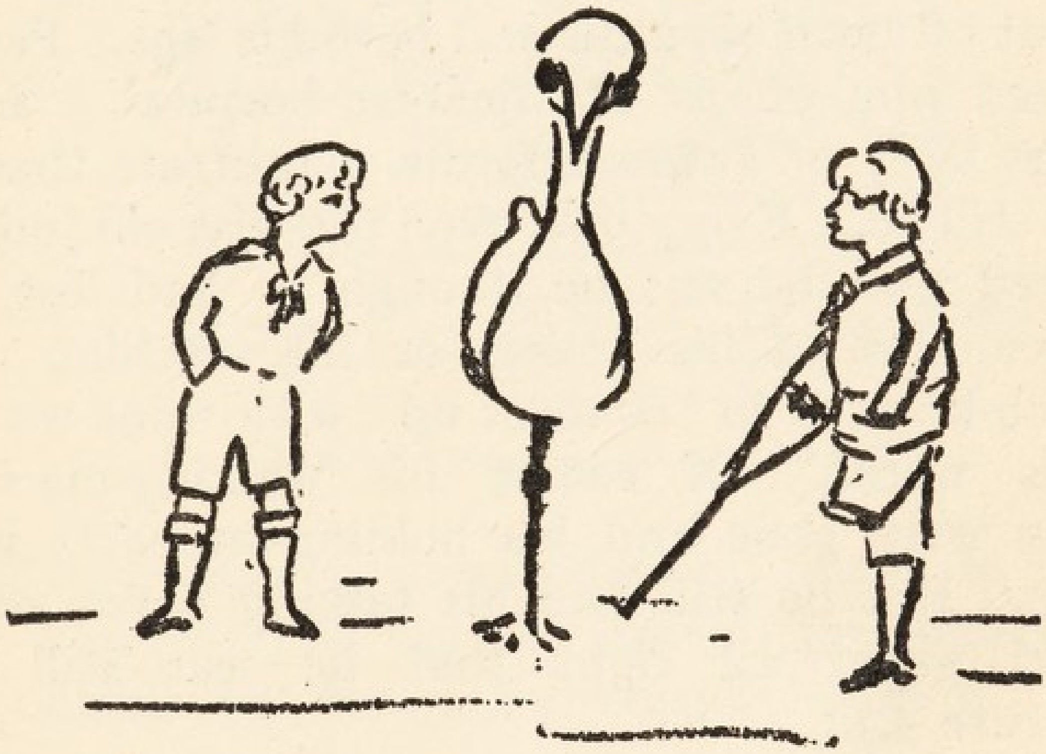
" Righto!" in chorus this time.

" Well, you are sure *they* are not I?"

Popping eyes were the only response.

" Just before we begin, give me my hat, will you?" (Picture 2.)

" Are you sure it is my hat? All right, it isn't I. Thanks. Put it on my head, will you? Sure it is my head? Well, then it isn't I."



3. " He is the same Billy exactly."

" But, father, why?"

" Oh, you think my head is part of me. Do you remember when Billy had his leg cut off? Billy is still the same Billy, isn't he?"

" Rather."

" But he has only got one leg to perch on now, like a stork asleep. So you see he couldn't be the same Billy if his leg were really part of him, could he? He must be some one else. Do you think that he is John now? You just ask him!" (Picture 3.) "That's right. He only lost a leg. He is the same Billy. You lost that knife I gave you, but you are the same old scaramouches, whatever you lose, aren't you?

"Here is a story. A friend of mine, a dried-up, tough old Indian general, slipped off the platform at a station one day, and the train ran over him. It cut off both his arms and both his legs. People rushed him off to the nearest hospital. Some hours later he swore before a magistrate that he was still he. Every one, even the wise old judges, agreed that he was he, though he had lost the larger part of his house—or his machine with which he used to 'connect up' with what we call 'this world.' Of course his walking-machine parts were gone and his holding-on parts were gone. But he still had his talking parts, so he could swear all right that he was still he. (Picture 4.)

"Remember that our bodies are not we ourselves. Contrariwise! They are ours. We lose bits of them sometimes. We often spoil parts of them, and some people spoil the whole of them. That is terrible, isn't it? And that is why I say that you must never do anything to spoil your body. Make it the very best body you can. It is the most useful possession you will ever have, and it is all your own. Indeed, you cannot do without it. When it is all spoiled, you must go to some other world, where you *may* get another one.

Let us pretend we are building a good one for somebody in this world now. We will begin to-morrow; and never forget that the building of

4. "He could swear that he was still he."

your own body is, from now on, largely in your own hands. You are the general manager, and responsible for it and for everything in it."

CHAPTER III

THE LAW OF LIFE

"BEFORE we begin to-day I ought to tell you that there are still lots of Hows and Whys that no one knows the answers to—yet."

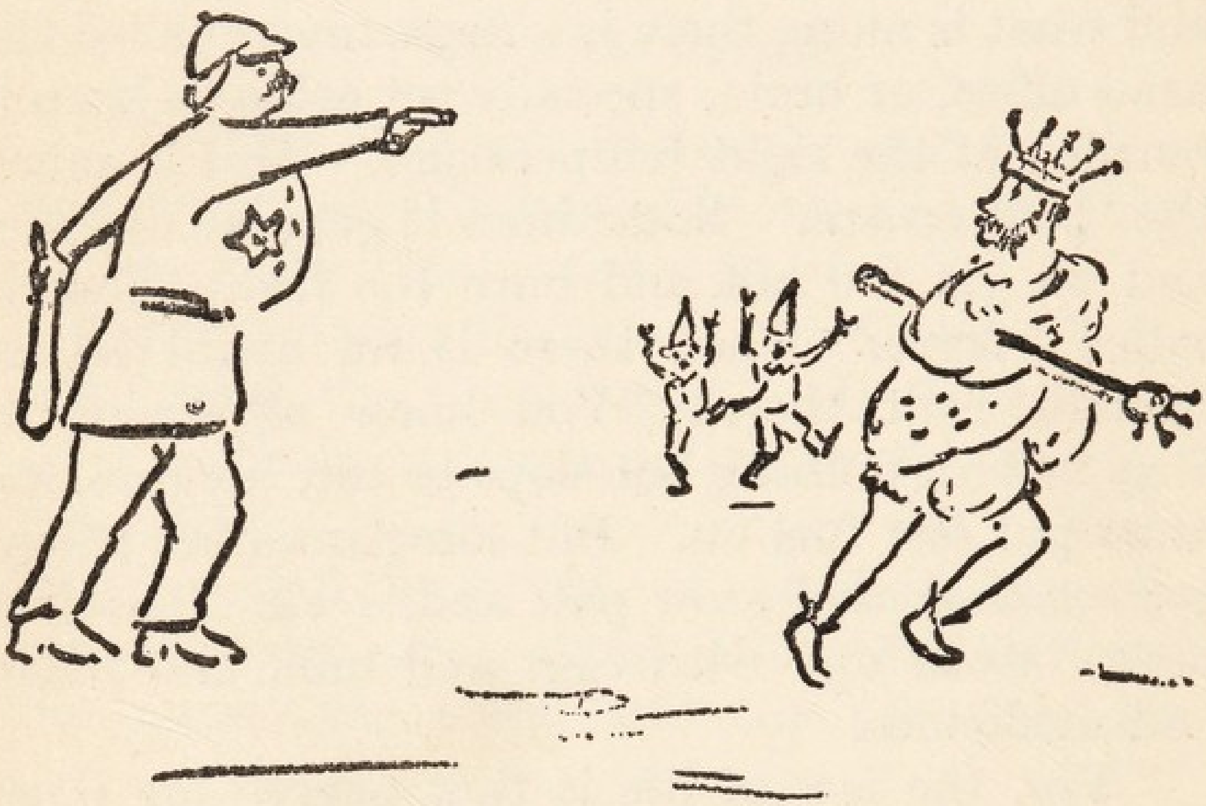
"But can't we find them out, father?"

"I hate the word 'can't.' If we are really alive we shall, of course, go on trying—that is the law of life. It is 'move on or die.' Nothing stands still in this world. Everything keeps in its place because it is moving, just as the earth itself, the moon, the stars, and the very sun itself, move."

"But the rocks stand still?"

"The rocks? Why, the tiniest atom of every rock is moving, as everything else is. Rock, like everything else on earth, is only made of little particles of electricity, called electrons, which dance around a centre—and they are always changing their positions. Your own body, which you thought the other day was you, and therefore was always the same, is really always moving on. Some of the little electrons in dancing about fly off and destroy the shape of other old particles, changing them so as to improve your body and to keep it always ready for you to use it as you grow. Most of this is done by what scientists call 'oxidation.' That is almost exactly the same thing as slowly burning up what is no longer any good. Isn't that strange? The body is always being burned up without our even knowing it; and what is more, there is a department called the head office, or brain, specially set aside to keep it burning at the right temperature. This is called the 'heat centre.' Sometimes it gets out of order and we get too hot and burn too fast. That is called 'fever.' Then there is an awful lot of trouble, isn't there? You know all about it. Stay in bed, nothing but slops to eat, because you must put less fuel on. But sometimes our bodies get too cold, and grow pale and weak. Then we must 'stoke up' with eggs and milk and jellies and medicines.

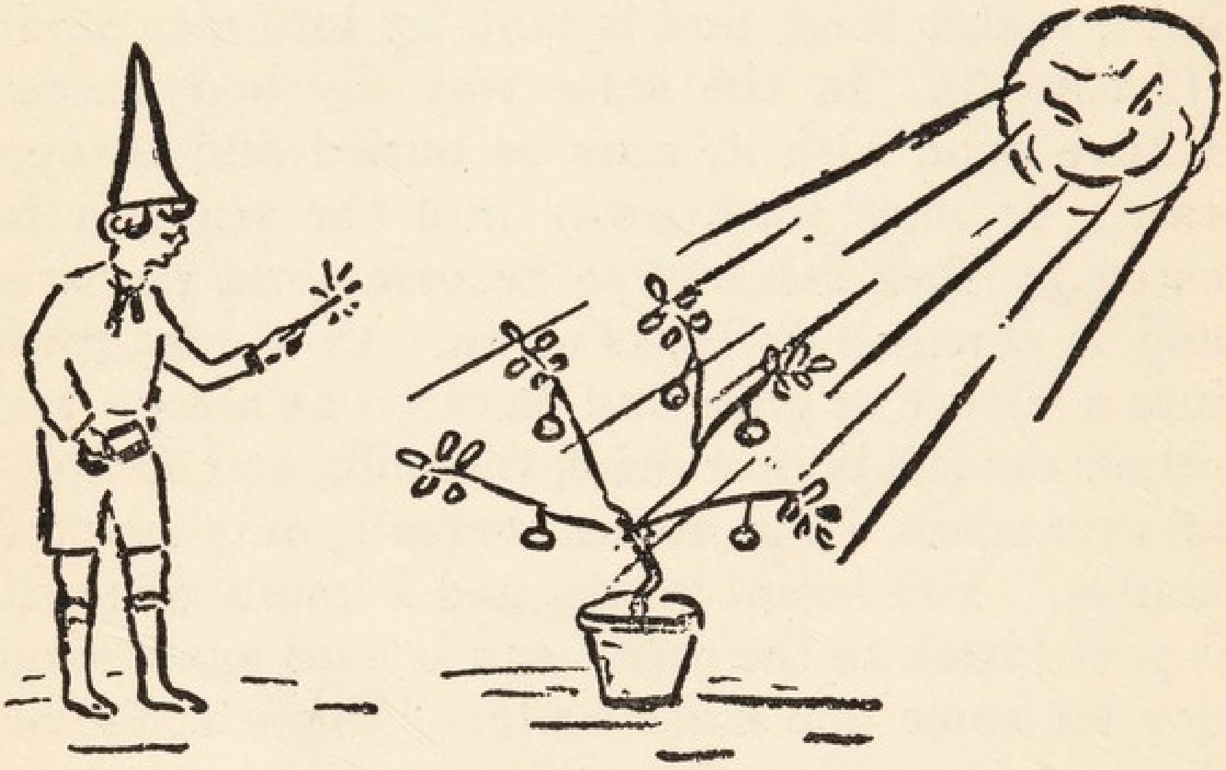
"Yes, the law of life is that everything must keep moving on—as the policeman says to the traffic: 'keep moving.' Even kings have to move along and leave their thrones behind them. Everything everywhere must be busy trying to build up a better world, or sooner or later it will have its life taken away from it altogether. Death is stopping. All that is good has come along by moving. For instance, we *had* to see farther, so some one had to start moving and invent a telescope. We *had* to see smaller things, so some one thought out the microscope. We *had* to move faster, so some one found out about steam and railways, and gasolene and automobiles, and aeroplanes and submarines. We wanted to see through solid things, so the X-ray came along. We had to talk farther, so some one moved on and found out the telephone and the wireless.



5. " Even kings must move on."

Moving on, moving on, moving on—is the Law of Life." (Picture 5.)

" However careful you and I are of our bodies, each body has really to be always like a city in war time, on the 'qui vive' all the time. For it has a thousand enemies which are for ever working to pull it down, to get inside and destroy it. Everything has. Even the rocks are the same; the heat blisters them, the cold splits them, and the water dissolves them; the drought powders them the wind blows sand against them and wears them down, the sea washes them away. But there is one comfort—in spite of all the changing nothing is ever lost. What comes off the mountains collects in the valleys and grows up into plants; the green stuff in the plants stores it all up with sunshine, and so it becomes fire and light, makes food, and is built up into men again (Picture 6). In the same way my body, when I have done with it, may be buried and become earth, or may wash away into the sea and be eaten by shell-fish and so become coral perhaps, and so change into rocks again. Or it may grow into a lettuce or grass and be eaten by a cow; and others eat the beef or drink the milk, and so use it all over again. Our bodies are really only haunted houses. You haunt yours, and I haunt mine till it goes 'back to the dust,' and is used again some day for some one else's body. 'Imperial Cæsar, dead, and turned to clay, might stop a hole to keep the wind away.' Even the rest of the sunshine that pours down is just the same. It isn't wasted either. It lifts up water to float as clouds, which come and rain on the crops, and make food for strength and rivers for water-power. It gets 'canned up' in wood or coal or oil to drive engines, or in wheat and fruits and vegetables for us to drive our bodies with. Even the winds are not lost. They stir the water and help to beat up rocks, and so turn them into heat and so on. The real fact is that there must be always two things or forces, as it were, moving in opposite ways, like the game of oranges and lemons. One is always pulling down; one is always building up. One is called positive; the other negative. Each is, as it were, holding the other in its place, keeping the other awake, and insuring that it does



6. (Left) Sunshine given out again that was stored up in wood by the green leaves.
(Right) Sunshine being stored up by green leaves and fruit.

its work, so that it keeps moving. See this mould on this blotting-paper? It is crawling toward that dirty water at one end of the table and away from this bitter water."

"Why does it crawl, father?" "Why? Well, because it is drawn there by messengers the dirty water sends, saying: 'Come. It is good for you.' We call that chemistry—it is really radio—and that is the way a White guard or detective learns an enemy is entering, even a long way off in the body.

" So it is that the Law of Life is struggling or trying, and that teaches us the only way by which you and I can ever succeed. There is the whole real fun of life. We, also, who live inside, have got to win out by trying, trying. And every one of us can be a winner if he will, because there is something bigger and wiser and stronger than we, and, like us, quite outside mere positive and negative blind force, always ready to help us. That is why we all ought to learn about it, so as to know what we can do to help. Mother did most of it for you when you were too young to know how to help. She saw that you were fed and kept clean, and slept proper hours, and went out in the sunshine, and did not hurt your body by doing foolish things; and she tried to keep it from infections as well as from accidents. But you, as well as your body, are moving on, and now you are getting able to take care of it yourselves. So, just as I told you before, what is not used is taken away, and at last mother can no onger fend for you, and her care is taken away also.

" There, again, is the fun of life—independence. Every one loves it and fights for it. We love to wave our flags which are our signs of it; but, as you have seen, neither we nor anything are *quite* independent. You are dependent on that porridge and cream which you ate for breakfast, and those eggs and butter. You could not live without so simple a thing as water; that is, your bodies could not. They are nearly three-quarters water, anyhow, and water is only two gases joined together—and the gases are made up of little particles called electrons. All the same, you and I did not teach electrons to become butter; we depend on something else to do that. We do not believe that you or I are ever electrons, or ever have been. We just use electrons. While you have been listening to me your body has been changing."

"Has it really, father?" and in spite of all I had told them their eyes were popping again.

"Why, of course it has. Your baby body changed every part until it was all gone. Here's a picture of you as you were then." (Picture 7.)

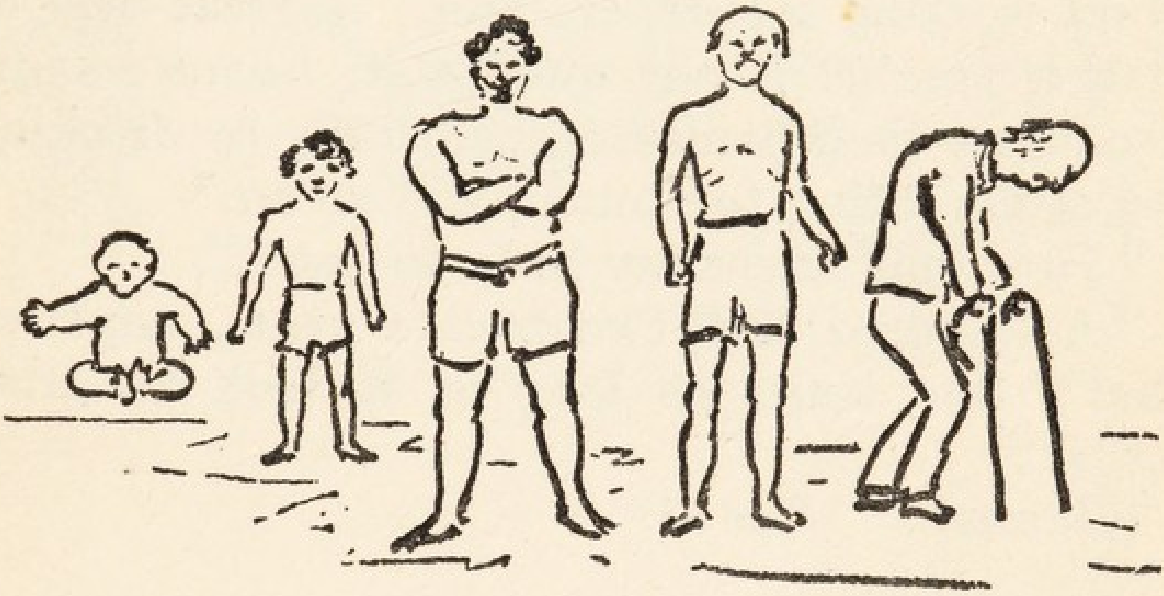
"How would you like never to grow up and always be imprisoned in a baby's body, or even a small boy's?"

"But, father, we didn't know we were doing it."

"Why, that's just it. You aren't doing it *all*; and here in this world, at least, you never will."

"Well, then, who does it?"

"That is another of the best things about life. It's a secret. Some people call it 'Nature' or the 'Life Principle.' You might as well call it any other lot of letters, because no one has the faintest idea what 'Nature,' or 'Life Principle,' means. I don't call this 'it,' but 'Him,' because it is a power so infinitely cleverer and more wonderful than I. I know that He must be vastly bigger and wiser and better and stronger than I, so I call ' Him ' God, and I hope you will. All this makes life intensely interesting, doesn't it ? "



7. Your five stages in life.

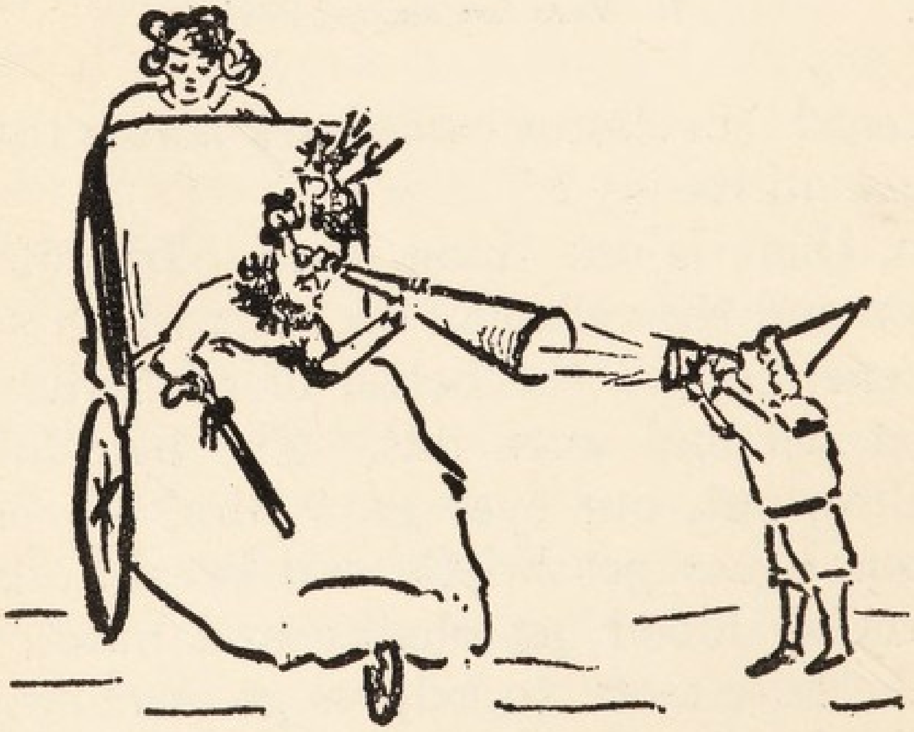
" Great ! " in chorus came back across the table. " Is that all to-day ? "

" No, there is one thing more. In spite of all that you and the cells can do, after about seventy years, enemies get the better of all bodies. The cells get old and worn out. The hair falls, the teeth drop out, our eyes grow dim, our ears get deaf, our bones get brittle and break, our pipes for carrying blood get chalky and burst. Then we make false teeth to help us go on chewing our food, till finally we have to go back to drinking milk as we did when we were babies. We make spectacles for our eyes, and trumpets for our ears, like those grandmother used (Picture 8,) and caps and wigs to keep our heads warm, and sticks and crutches and wooden legs, and invalid chairs—till at last we give it up, and don't die, but just leave the wretched old body and go into another world and hope to get another body, so as to go on working somewhere else. A great deal of all this trouble is our own fault, because some men abuse their bodies so shamefully by drinking bad stuff, eating too much, and so on."

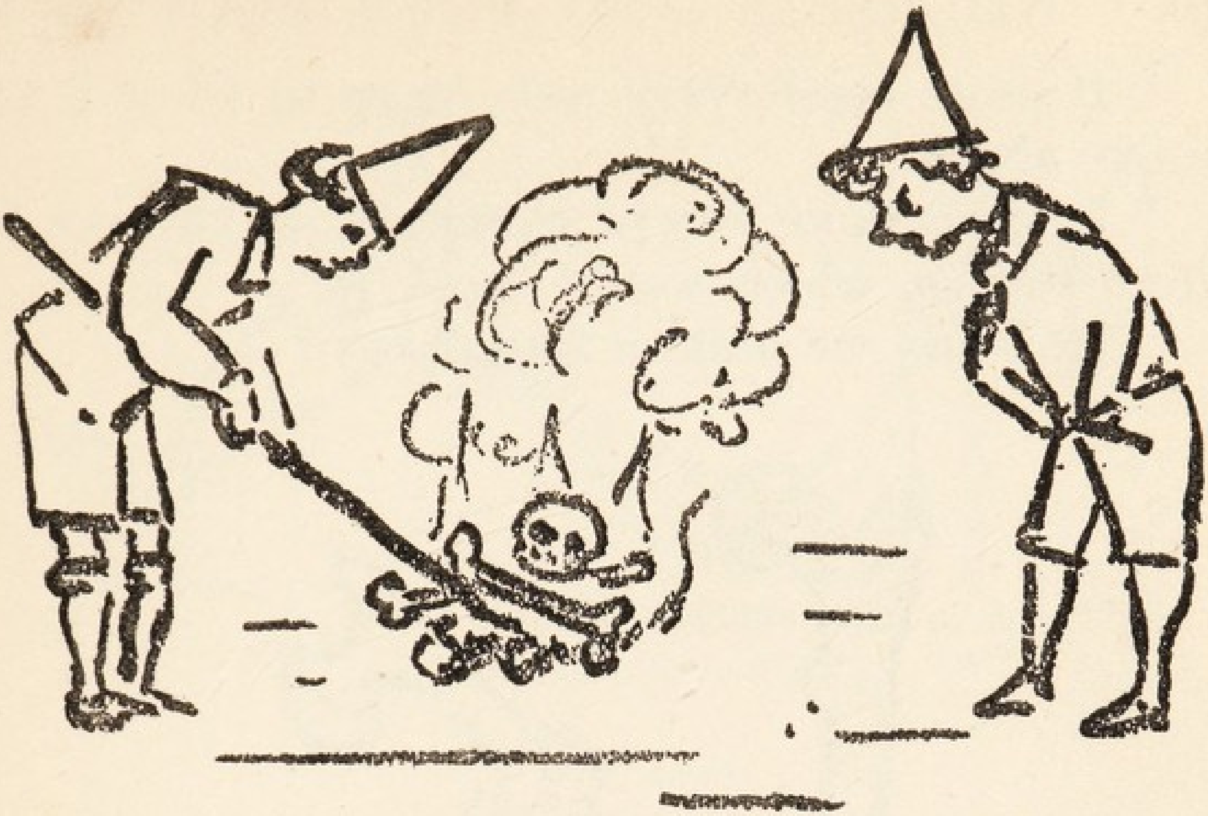
" How long ought my body to last ? "

" A hundred and twenty-five years, anyhow. That's five times as long as it took to grow perfect."

(Chorus) : " Gee ! ! "



8. Ear-trumpets like grandmother's !



9. It all goes up in smoke.

CHAPTER IV

THE FRAMEWORK

"THE first thing about a house is the foundation, isn't it? Well, this isn't going to have a special one except that the whole universe is its foundation. It is far more wonderful. This house has got to run and jump and tumble around—so that is one thing less to worry about.

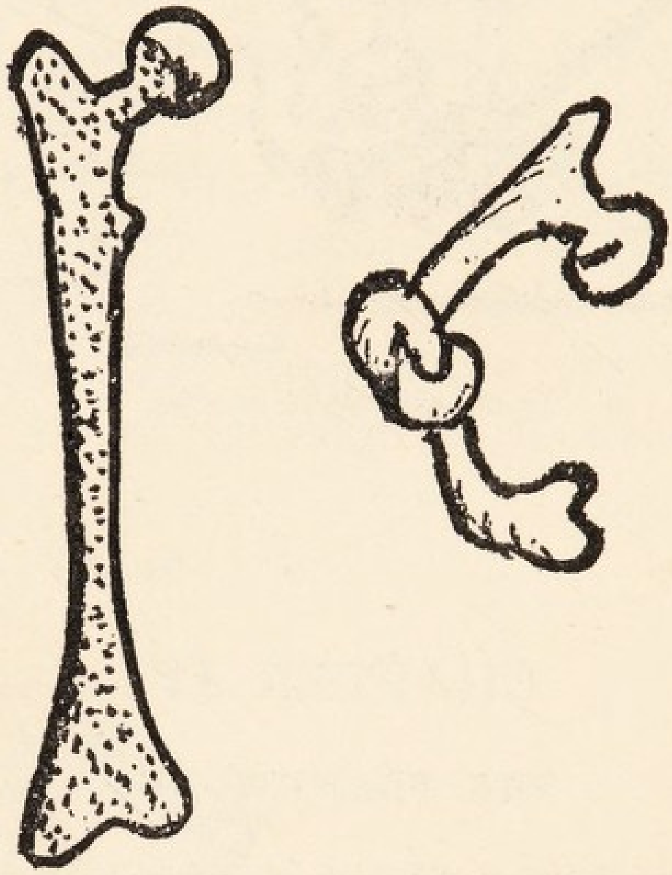
"The next thing is a frame. It is the most wonderful frame ever dreamt of, because once you start it it grows larger all by itself.

"It must be upright, for man is the master of the animals.

" It must bend every way, so as to allow it to move about.

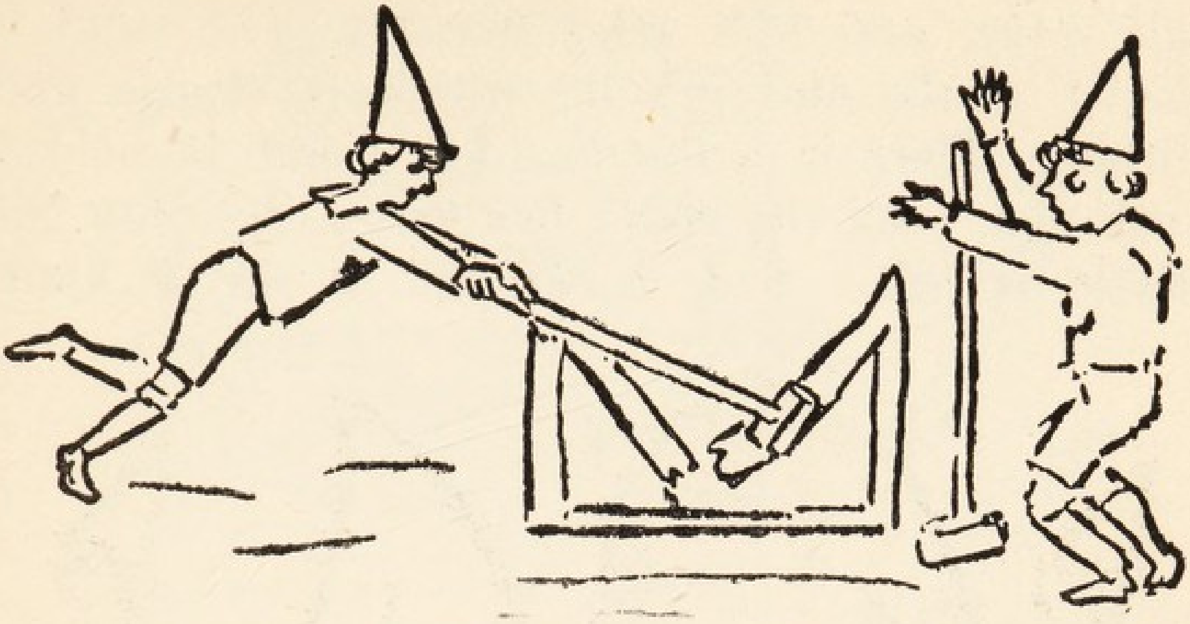
" It must have lots of elastic, so as to save it from shocks, which would break it."

" How can we build a framework ? "

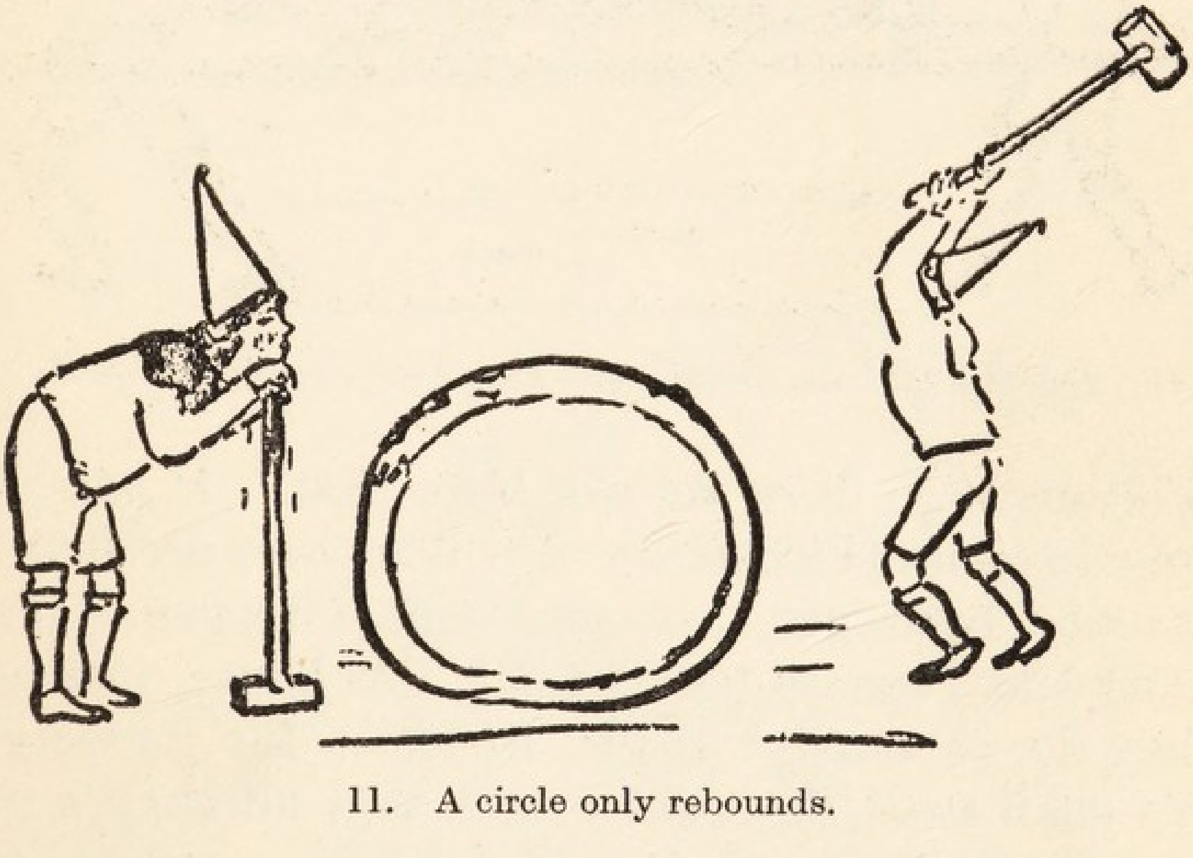


10. Bone stiff with chalk. The same after chalk is dissolved.

" We cannot use a frame of wood, as that would break, or of iron, as that is too heavy. We must use something ' bendy ' yet awfully strong and lasting. Let's pretend that we are making this framework. Some of the cells we spoke of make just what we want. The substance is called bone. At first it is soft, then, like concrete, it gets hard.

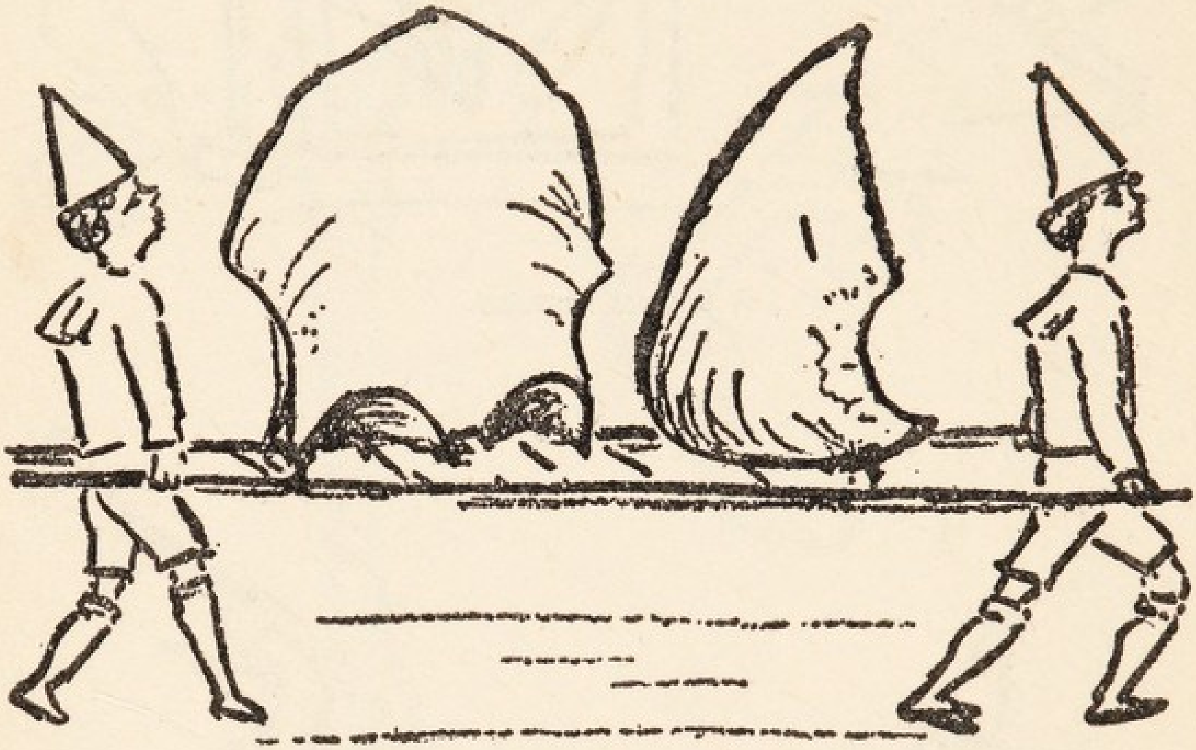


A square breaks.



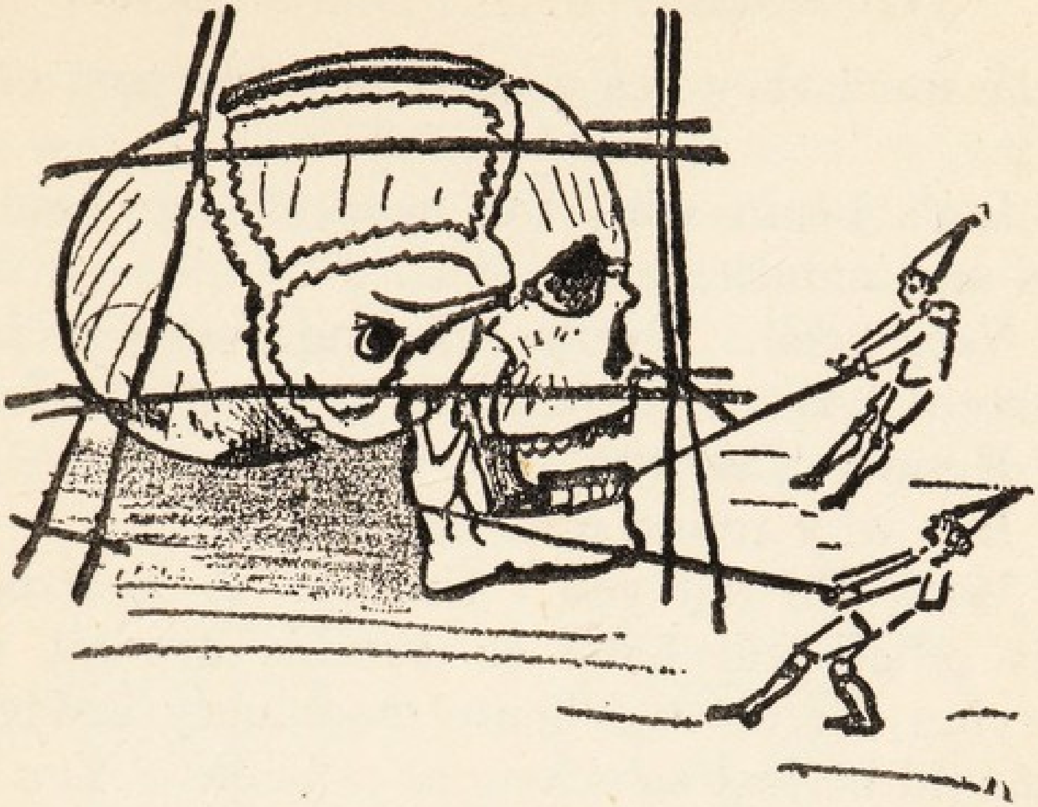
11. A circle only rebounds.

But it is far more marvellous than concrete, because it is alive, and the cells go on building and repairing it day and night all the time. They use half water and half solid matter. The solid is mostly chalk and gristle, which is elastic and fibrous. Here is a bone which I put in acid a week ago. All the chalk has gone, and only the gristle is left. See, I can tie it in a knot.

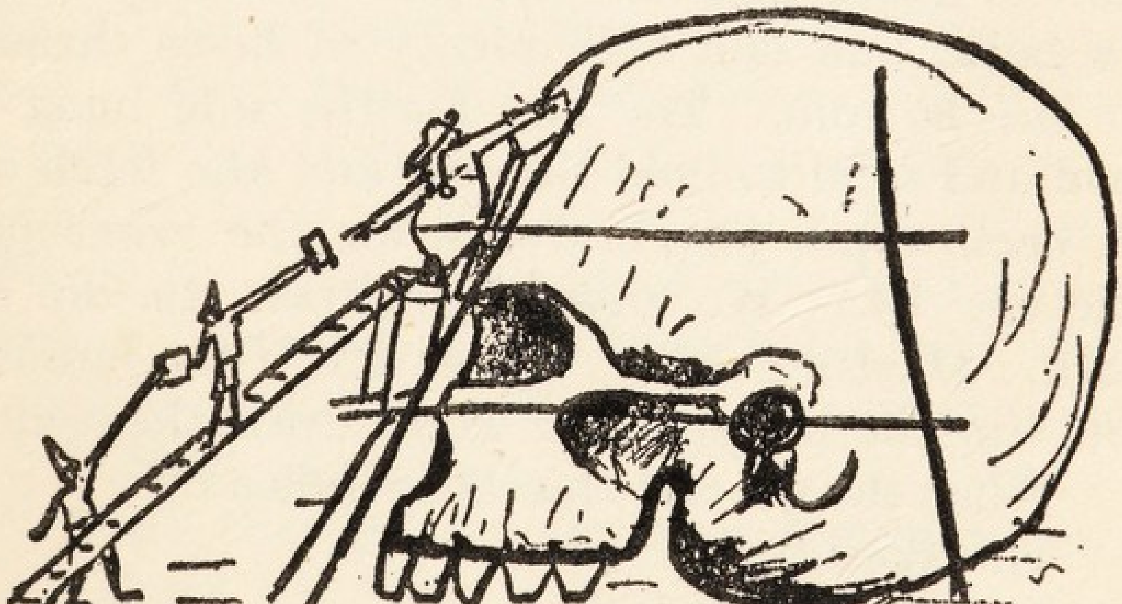


12. Shows front bone (frontal) and back bone (occipital) of skull.

(Picture 10.) Now we will burn that. It has all gone in gases (Picture 9), of which there are four : carbon, hydrogen, oxygen, and nitrogen. We must leave spaces between the flat bones, just as they do in cement roads, to allow for growing. We shall need flat, and round, and all shapes of bones. Some of them will be hollow, to make them lighter, except for a little marrow where the cells live which do the mending, and where new baby soldier cells are born, and live in



13. " One bone for the lower jaw."



14. " We must co-operate to build."

safety until they are needed in some part of the body."

"Let's begin with the head, father, and the eyes and mouth and——"

"Very well. Every building needs a headquarters. What shape shall we make it?"

"Round, of course."

"But why round and not square?

"Well, I'll tell you. Because it is stronger. This office will have to tumble around while carrying the most delicate machinery inside; so it should be just as strong as possible. You hit a square box on the top and it will break. A round one will bend and bounce out again if it is not given an irresistible blow. (Picture 11.)

"Fetch along those flat bones for the sides and that piece with top plates for the eye-holes for the front (Picture 12), and the piece with a hole for the back, and one with plenty of holes through for the bottom. The one for the side must be good and solid to hold the ear, and also fetch one for each upper jaw, and one for the lower jaw. (Picture 13.) We must co-operate to do the work. (Picture 14.) There are two hundred bones in the body, so we won't draw them all.

"What do we call this bony office?"

"The skull."

"Yes, and what is in it?"

"The brain."

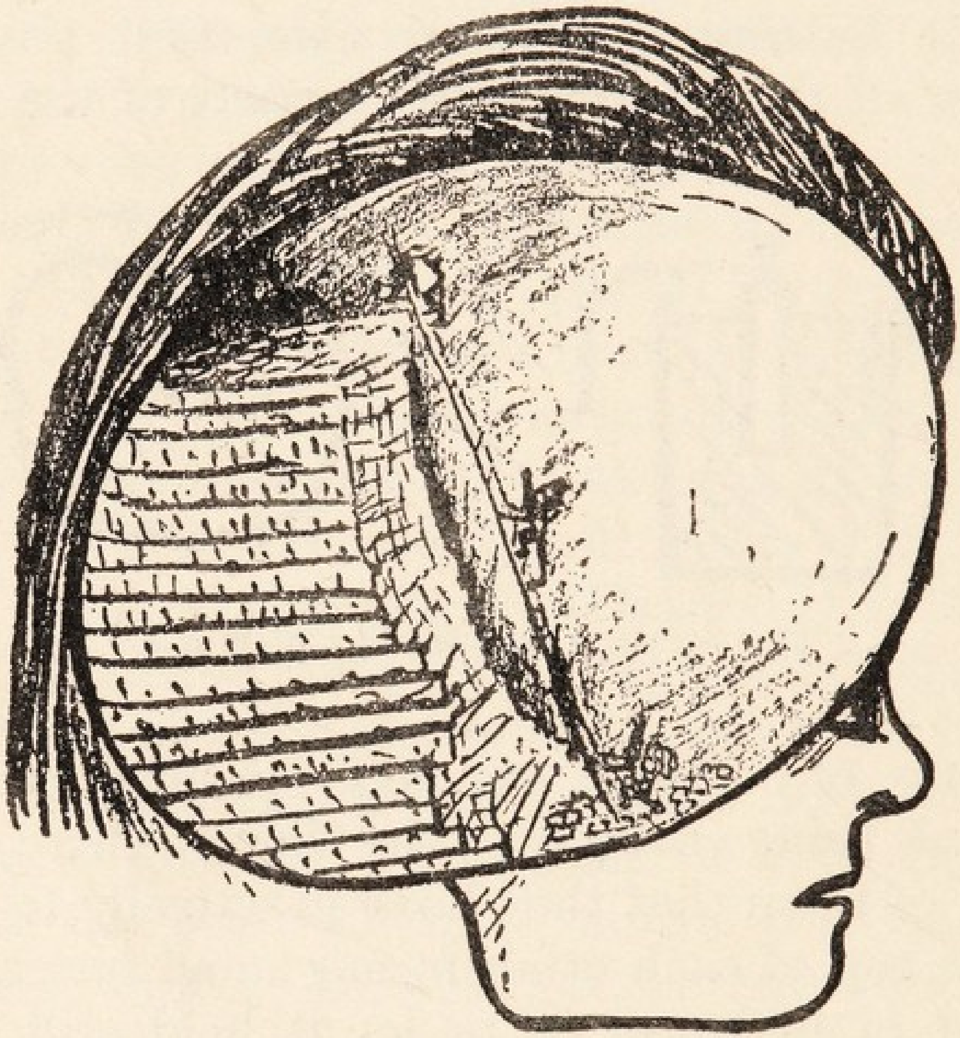
"Right; and what does it do? Why, it orders all the rest of the body about—and interprets all messages. In it are the cells with which we see and hear and speak and smell and think. They are soft, fat cells, making a layer more than four-fifths of an inch thick. Each cell is an electric battery or electric wire, that sends or carries all the telegrams to all parts of the body.

15. An electrical cell and a brain cell.

(Picture 15.) There are many millions of these cells, all being charged all the time. There are so many of them that they have practically to stand on the top of each other in our small box and be placed in folds, so as to let it hold still more. (Picture 16.) Here are some of them with all their wires in one cord going through the hole which we left in the floor. They are crumpled up and tied in place as you see."

"Won't they get all mixed up, father, when we jump about?"

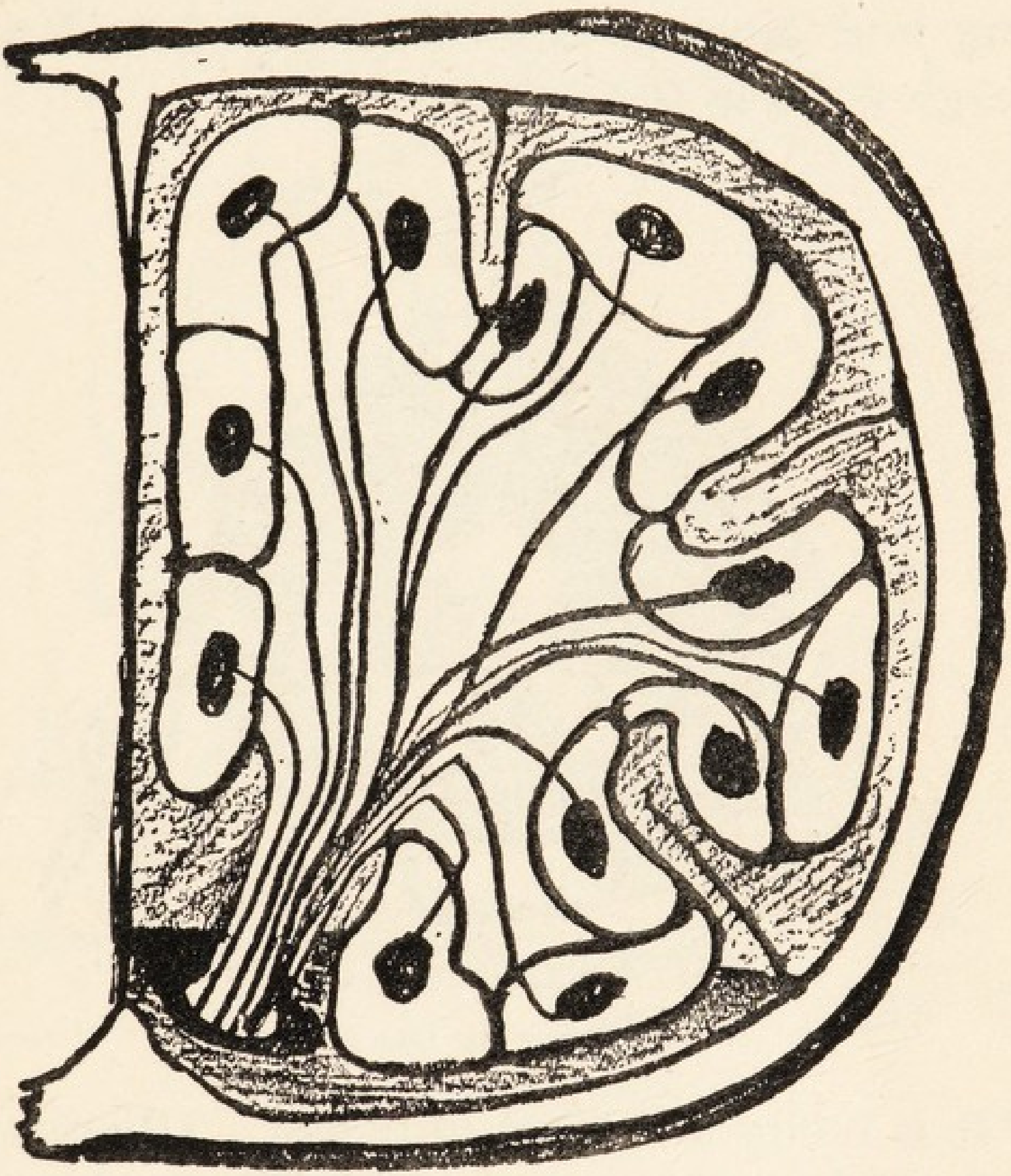
"Yes, if we don't put in plenty of shelves and then tie them all in their places, and put good oil-bags between them, and then a bone wall to keep them from bruising each other. You see here the cells and the wires on their shelves, and then the strong bag filled with oil round the



16. Piling up brain cells in their central office.

whole to prevent any banging of the cells as we move our heads. (Picture 17.)

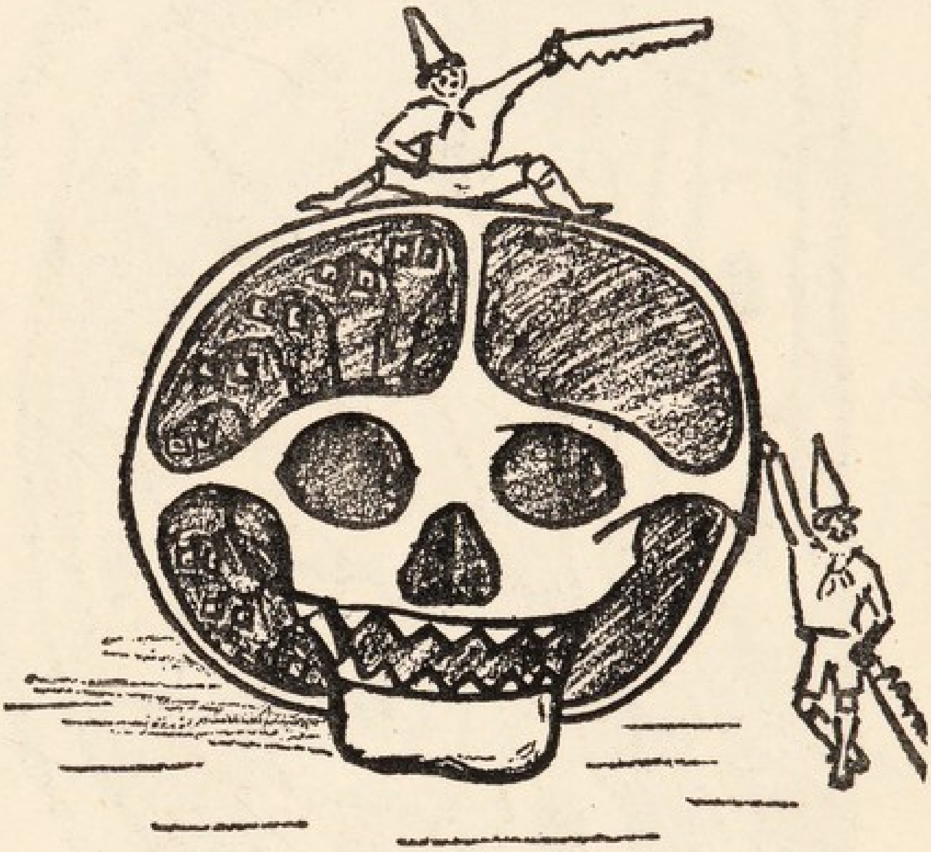
"Now we will saw the box both ways to show you how it goes. (Picture 18.) On the bottom are many ridges and holes, and now look at the middle compartment which holds the soft cells when we roll our heads. Isn't it a jolly fine box? It is all ready to wire and put the cells into.



17. Cells on the shelf and oil around them everywhere.

" You see, we use only one half of our brain. A left-handed boy uses the right side of the brain, and a right-handed boy the left. The other side is carefully kept in reserve, so in case an accident happens to one side, then we can learn to use the other.

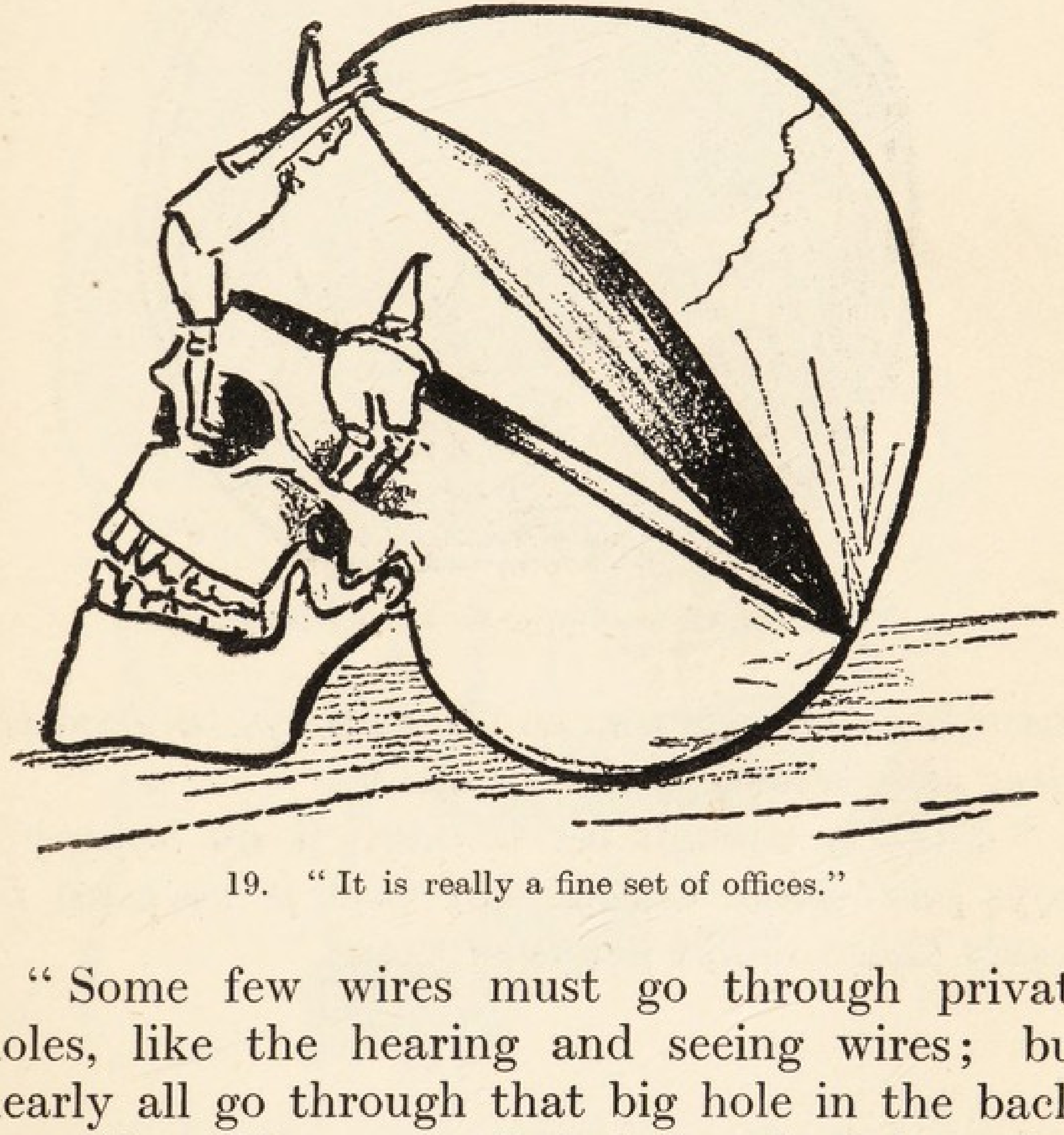
"Here is the whole skull sawed another way. The picture shows shelves for the eyes and nose and tongue and voice; the wires to the cells for seeing and hearing and tasting and talking go through holes in the bottom.



18. "We will saw the box both ways."

"It is really a fine set of offices. (Picture 19.) You see, the cells are outside. The keyboard on which you and I play when we direct the machine is at the front and on the top. It is one-ninth of an inch thick, and about as large as the palm of my hand; that is, about one five-thousandth of the brain controls the whole lot. But it is well folded and contains about a thousand million cells.

" The balancing key and cells are in the back, on the lower shelf, and all the cells that run the levers and engines are at the back, low down. It is the busiest repeating office in the whole world.

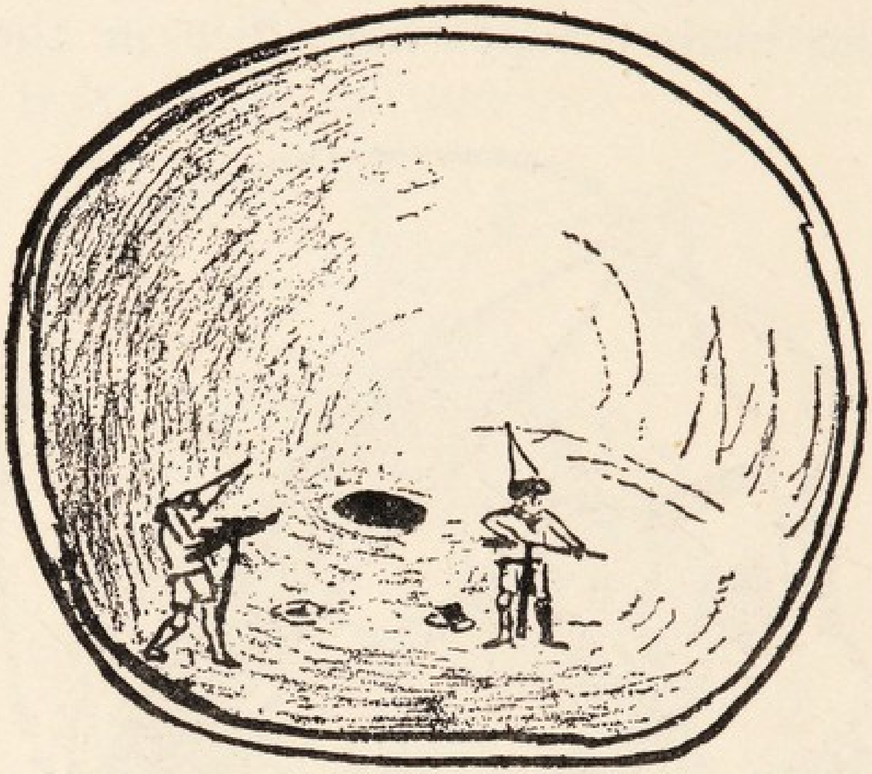


19. " It is really a fine set of offices."

" Some few wires must go through private holes, like the hearing and seeing wires; but nearly all go through that big hole in the back-bone, in a big rope called the cord of the spine. So we must make a few special holes in the floor. (Picture 20.)

" You see here how the little cords for the nose and the eye and the ear and the tongue go.

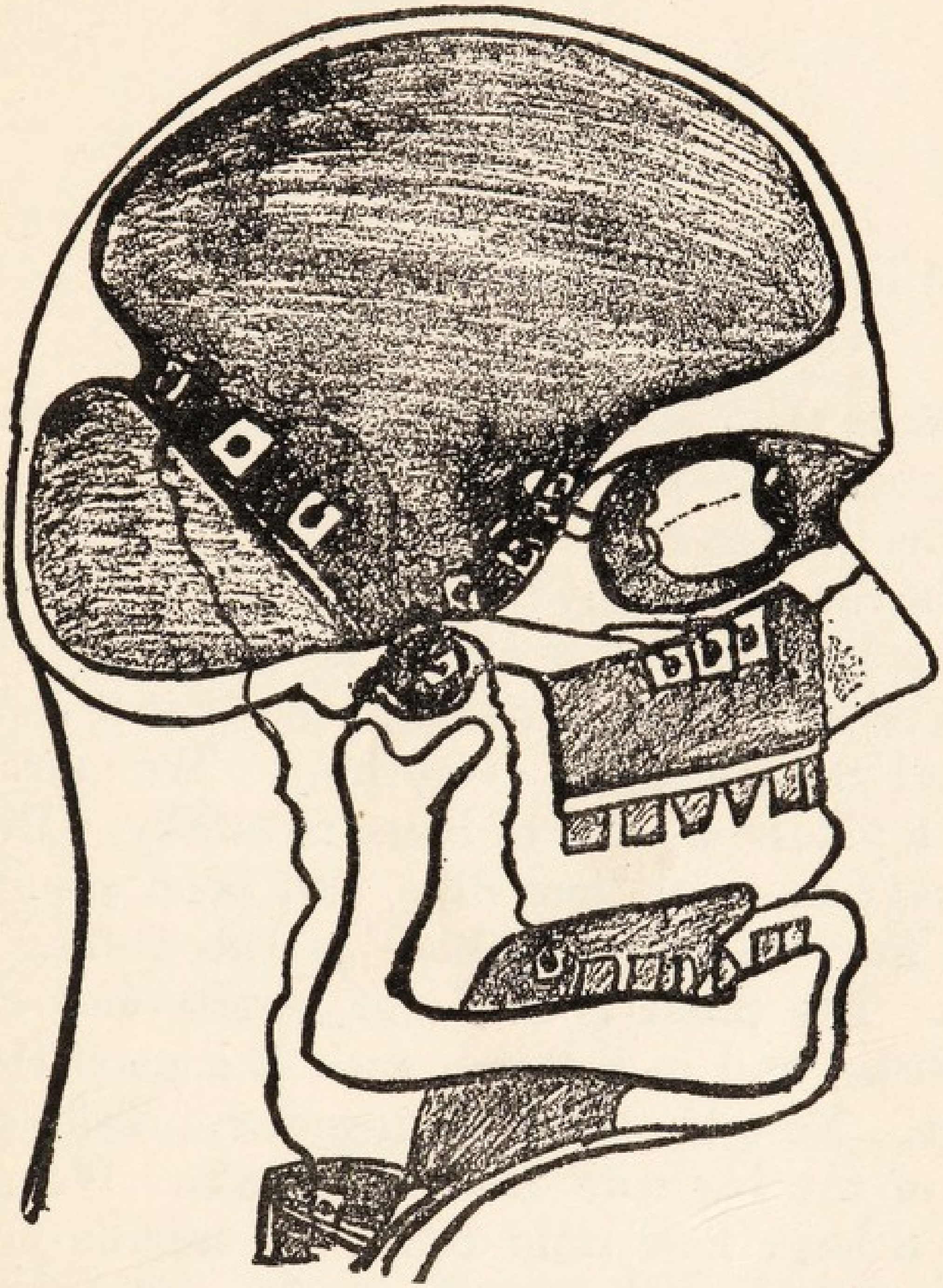
(Picture 21.) Cords also go to all the factories, to the heart to keep it pumping, to the lungs to keep



20. "We will bore holes for the special wires."

them breathing in air, to the kidneys to keep the filter cells working, and so on.

"That is enough for to-day. I do hope you boys have some brains, and that it isn't all fat inside those round heads of yours."



21. You see the special wires for Central to the eye, nose, and throat.

CHAPTER V

THE FRAMEWORK (*continued*)

The Spine and Chest

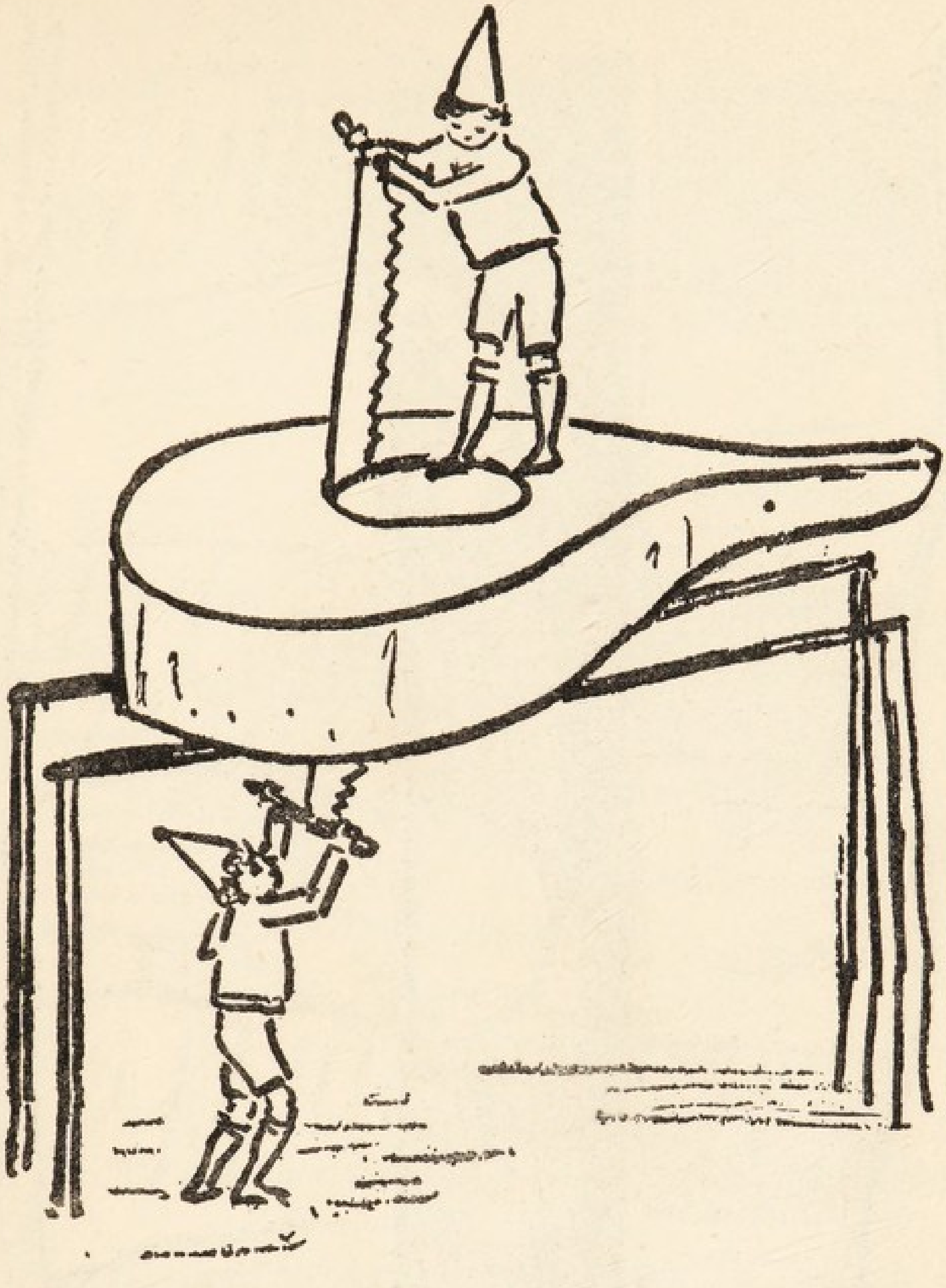
"Now that we have got the head and brain, where shall we put it?"

"On the top?"

"Of course! Why?"

"To keep a look out?"

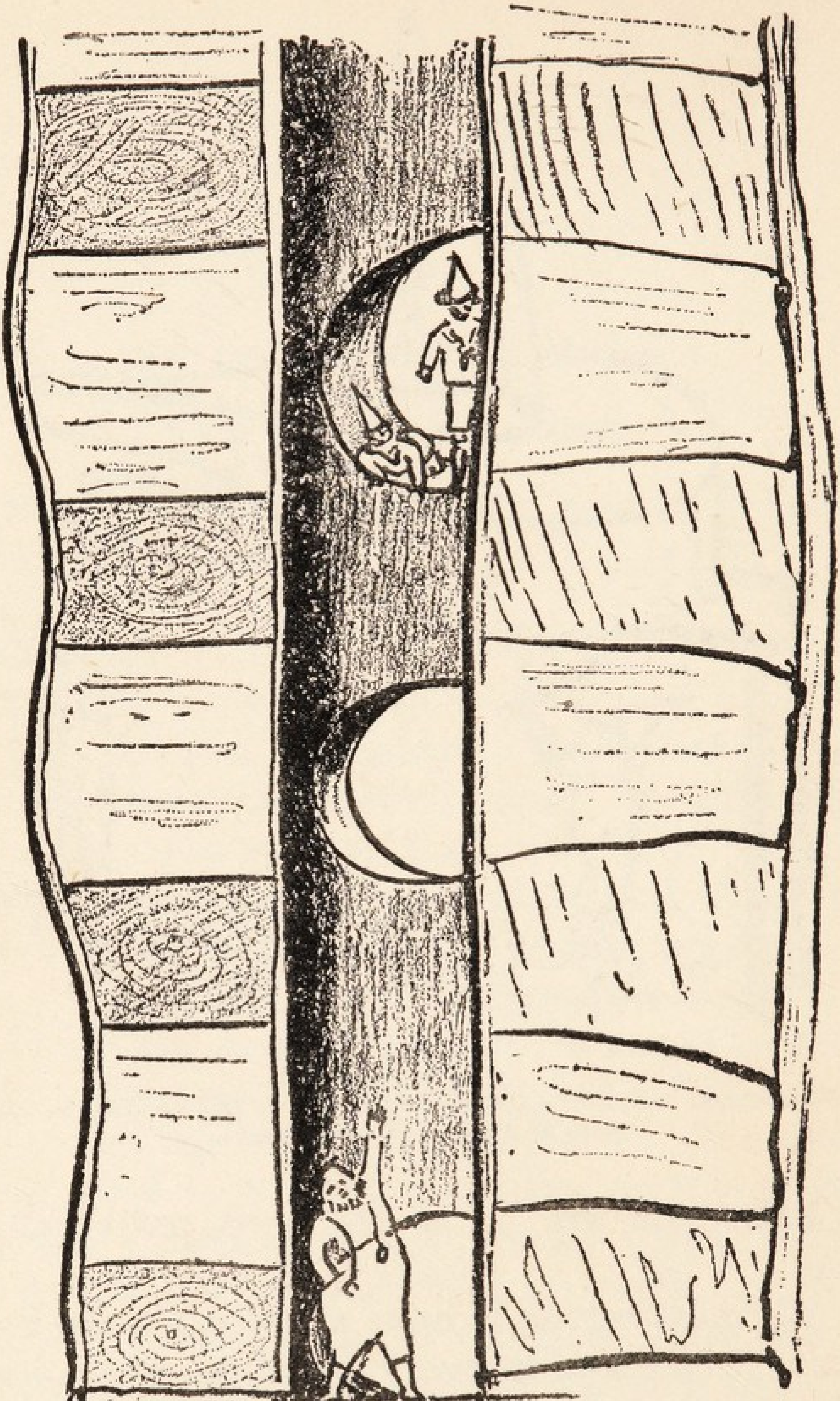
"Yes, just like a periscope. So that it can see around and command everything. We must put it on a pillar—a pillar of bone, naturally. But as we want to jump, and dive, and bend about we must have an elastic pillar. So this is how it is done. The pillar is made of twenty-four short flat disks, and in between each is a good elastic buffer. Now tie them all together. Take good care of the big cord from the brain. We must have a large hole right down the middle of the stick, and thread it through inside. (Picture 22.) Now we can saw the stick down its length and look at it from inside the holes which we have made. (Picture 23.) I am standing in the hole through which the big cord of the spine runs. Side cords to each part of the body pass out through



22. Sawing the hole in the spine (or vertebra) to thread the great nerve trunk through and keep it safe.

the holes you are in, as the cord passes along down.

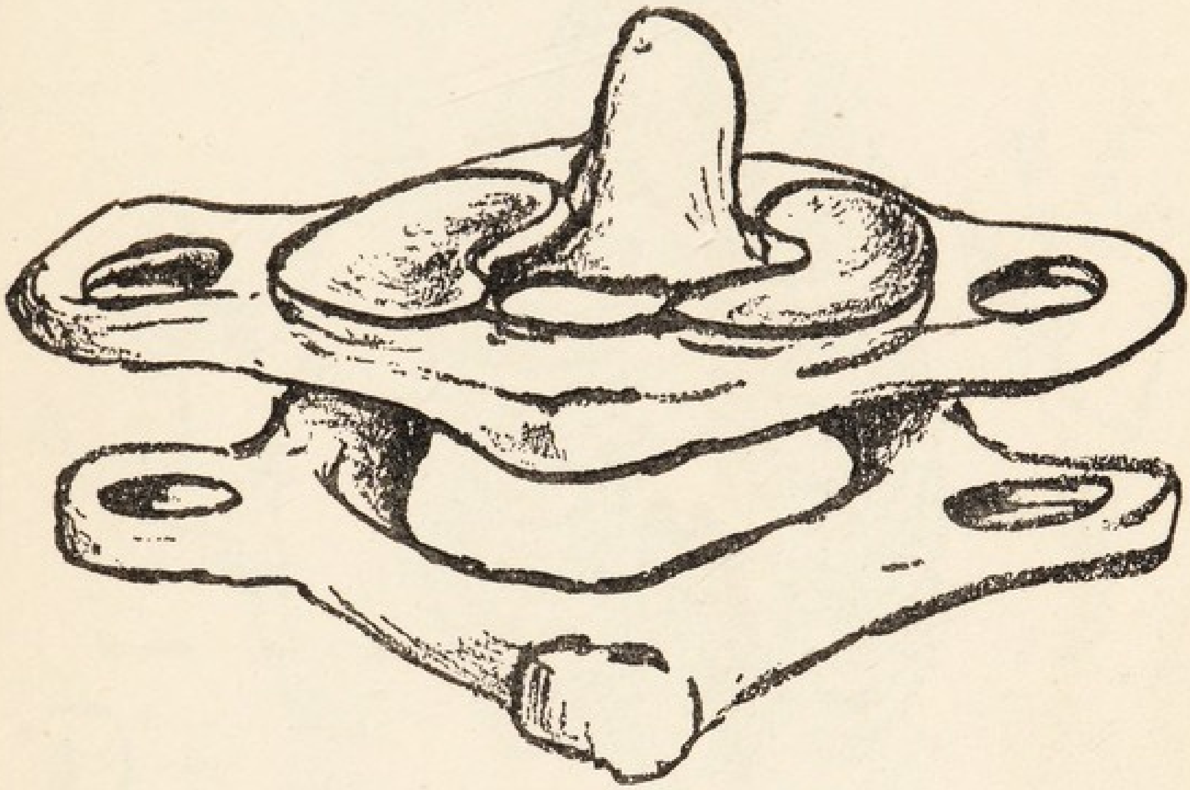
"We must certainly have a socket for the head so that it can turn in every direction, and we will have a big peg up from the block below to keep the top block very, very firm. Here you see the two



23. The strong safe tube in the spine for the main wires.

top blocks. The head sits on this one. (Picture 24.)

"Now we will hoist her up on the pillar, or spine. Here she is—able to turn and bend any way. The bones are tied by bands or fibrous



24. The spindle that holds the head on top of the spine.

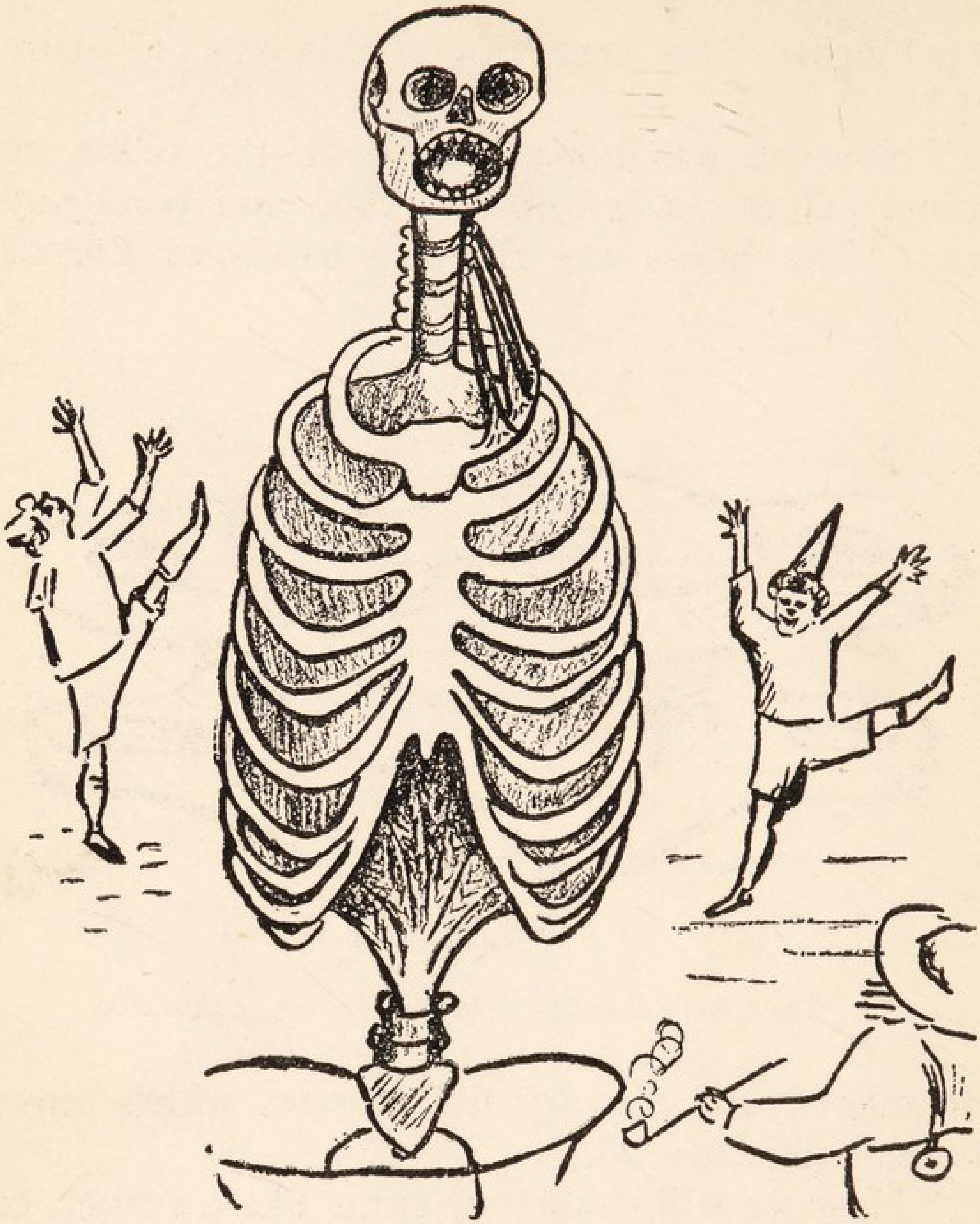
ligaments, and also by the muscles which move them. (Picture 25.)

"Now we will shake our spine like a carpet, to see if it is properly supple. (Picture 26.)

"When I want I can move my arm or leg, can't I? Well, when I am asleep I don't want to, do I?"

"No."

"I can't, however, move my heart when I like, and make it beat?"



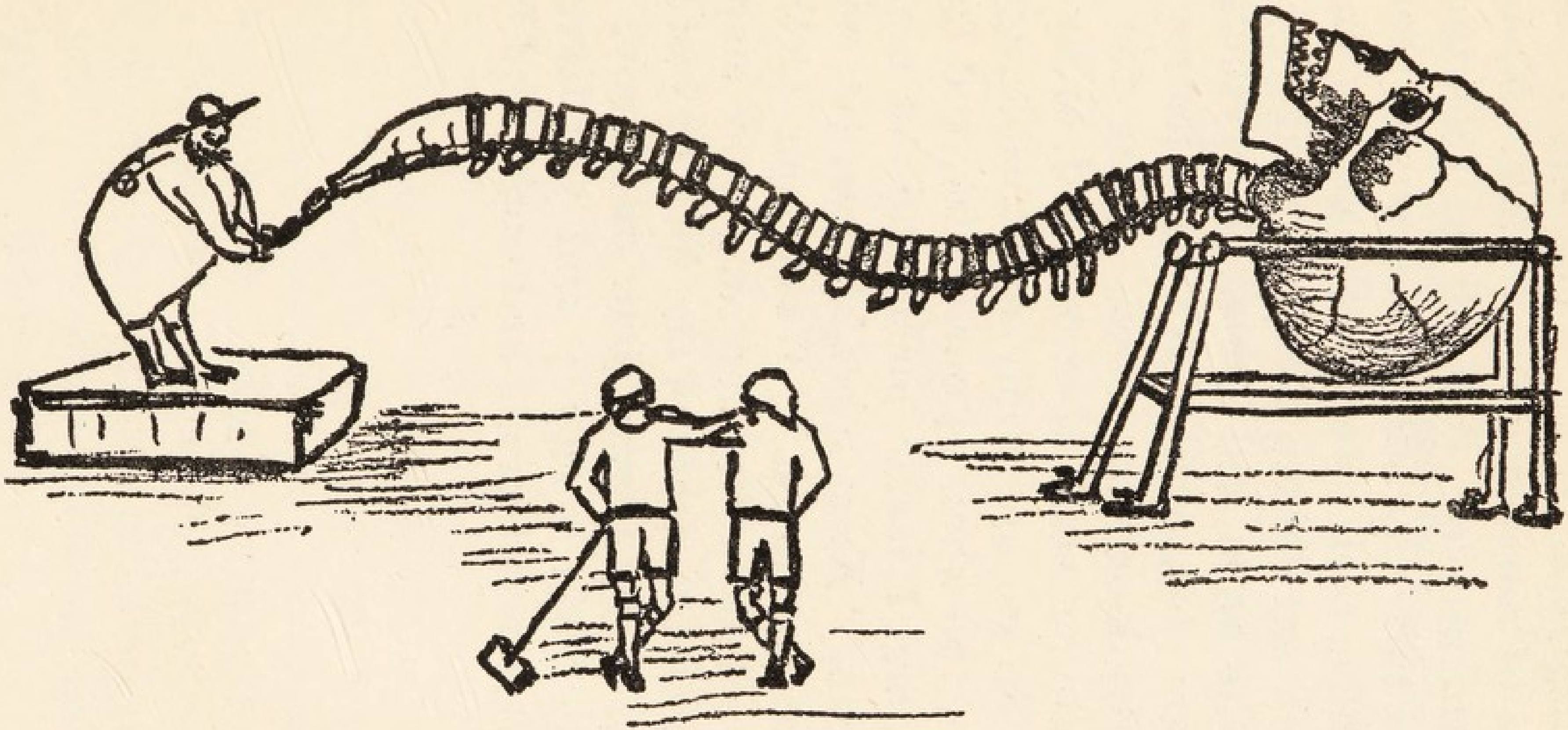
25. A jolly fine strong box.

" No."

" But I do want it to beat when I am asleep, and it does?"

" Yes, of course."

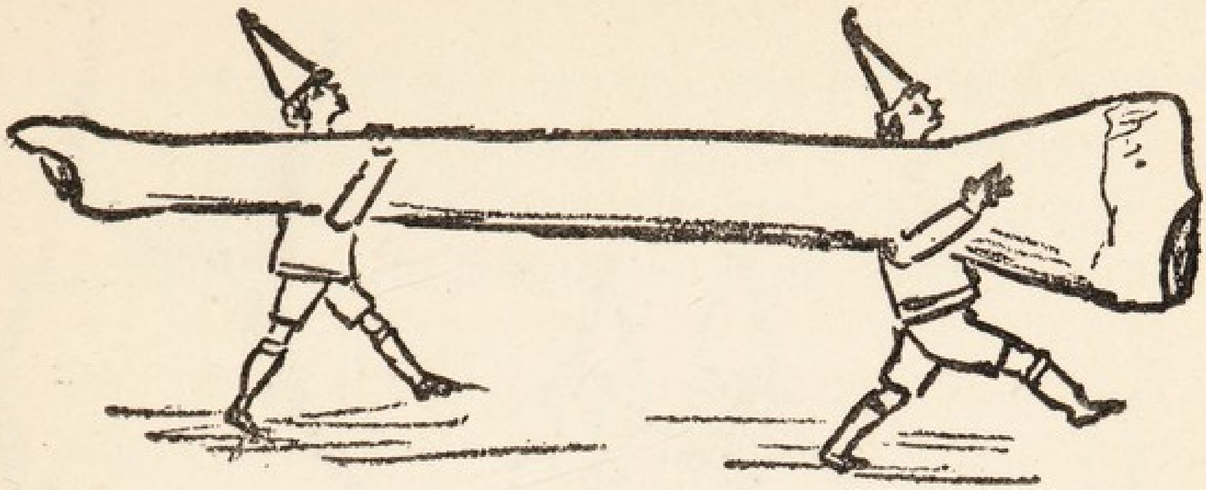
" So we want to go on breathing all night when



26. See how supple the spine is.

we are asleep, and we do. You and I can order only some of our muscles to work. The others go on by themselves. We call the cells that keep us alive in this way automatic or self managers, and they have their own wires or nerves, and their cells, which are hidden away in their own workshops in the brain and spine. Everything stops if these are destroyed. We can destroy those cells by drinking too much, eating too much, letting them get starved or over-fed, or by taking poisons. So we are really responsible again for the care of the whole of our bodies, and from the office you and I, inside, must send out messages: 'Keep clean,' 'Keep sober,' 'Open the window,' 'Don't eat too much,' 'Wash your teeth,' and especially: 'Go every morning and empty out all the waste and ashes of the food of yesterday.'

"If you really govern your own body, you do more than 'win a city'; and you have every chance to grow up strong and useful and happy."



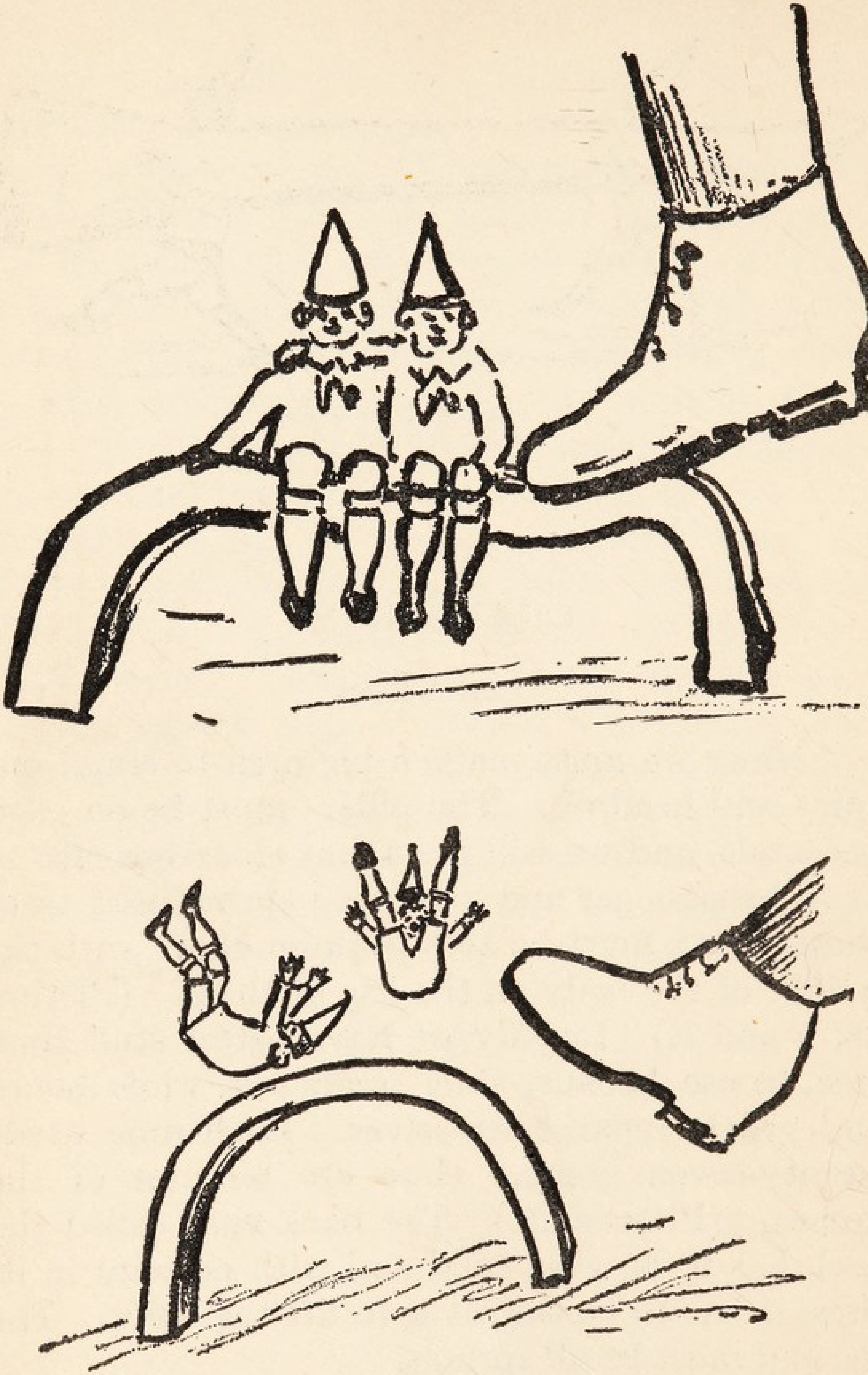
27. Bringing the tibia.

CHAPTER VI

THE UNITS

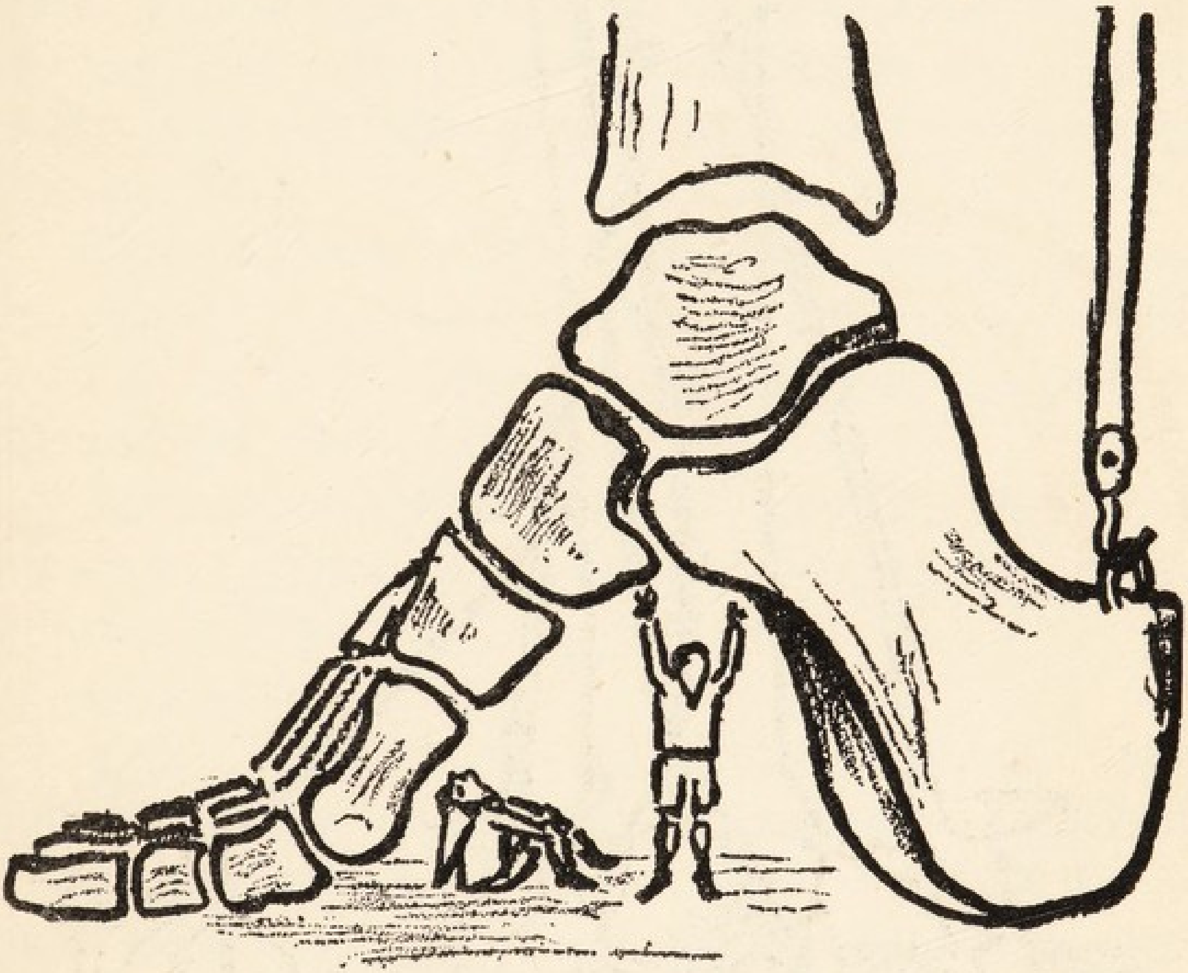
"NEXT we must make a big arch to stand our spine and head on. The pillars must be on good pedestals, and we will put them on arches also so as to be stronger and give good springiness, since these pillars must be able to jump about with the weight of the body on the top of them. (Picture 28, *a* and *b*.) Luckily we have better stuff than steel to use, because steel wears out, while bones and gristle repair themselves. Each arch needs twenty-seven bones. Here are pictures of the arches. (Picture 29.) The back end, called the heel, has to be very solid and with no joint in it, since it has to be the lever to lift the body. The toe end must be all springs.

"Now bring two good long bones to put on the top of the arch. There must be some play again



28. Almost everything has some elasticity. This piece of steel shows it.

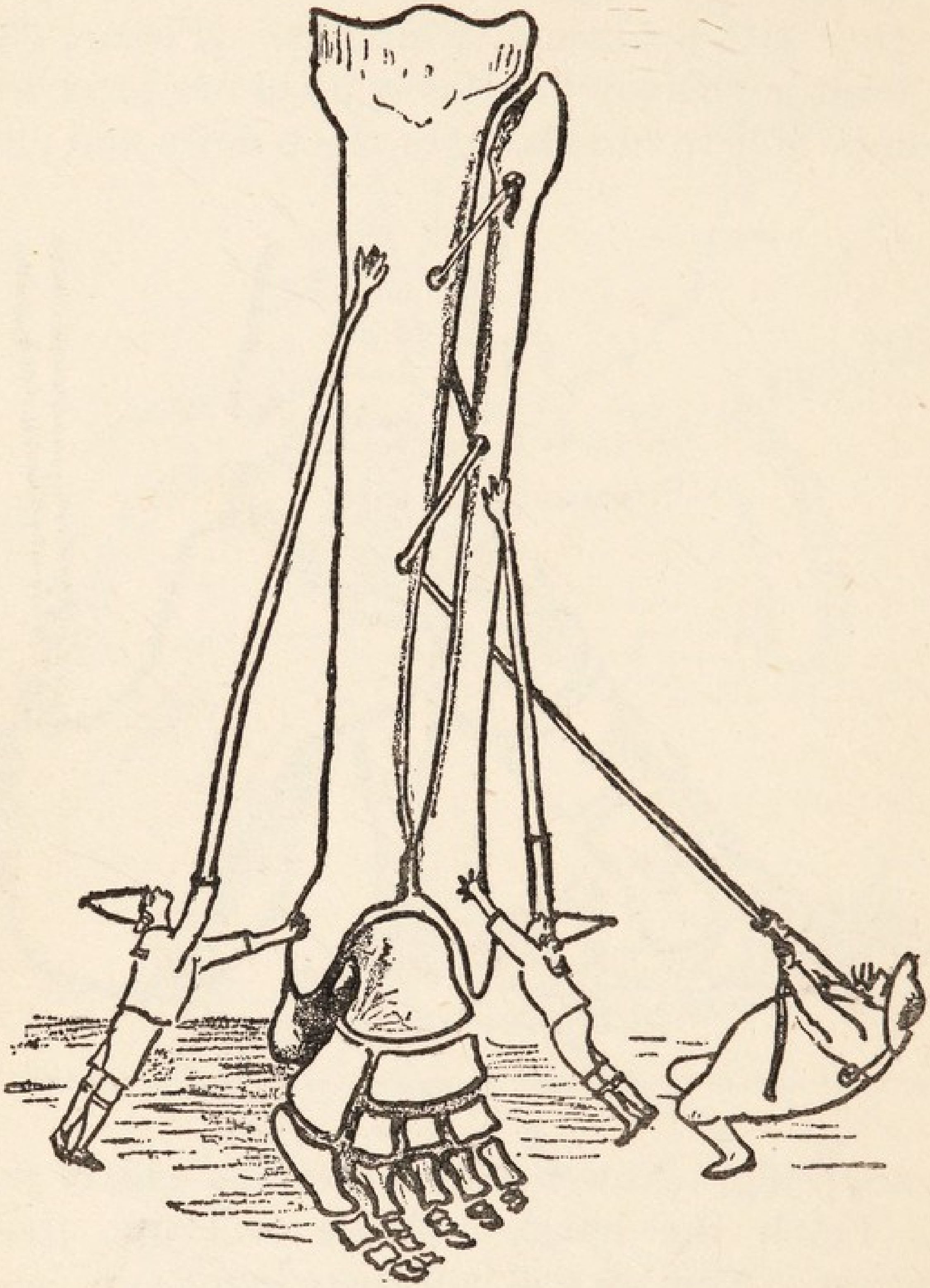
to prevent breaking, so we will just lash these together with ligaments or binders. (Picture 30.) We must have a joint half-way up or our body will never be able to run about, or stoop down and pick



29. The arch of the foot and the tendon for pulling up the heel.

up anything. Now we must get the pillars put up. Fetch the bones and we will put them together. Now we will call these legs.

" Now for the next pillars. They must go on the top of the last like topmasts in a Marconi station. They must not be tied to the side like common poles, but balanced on the top, and even then with spring enough to bend and run and



30. Lashing the leg-bones together.

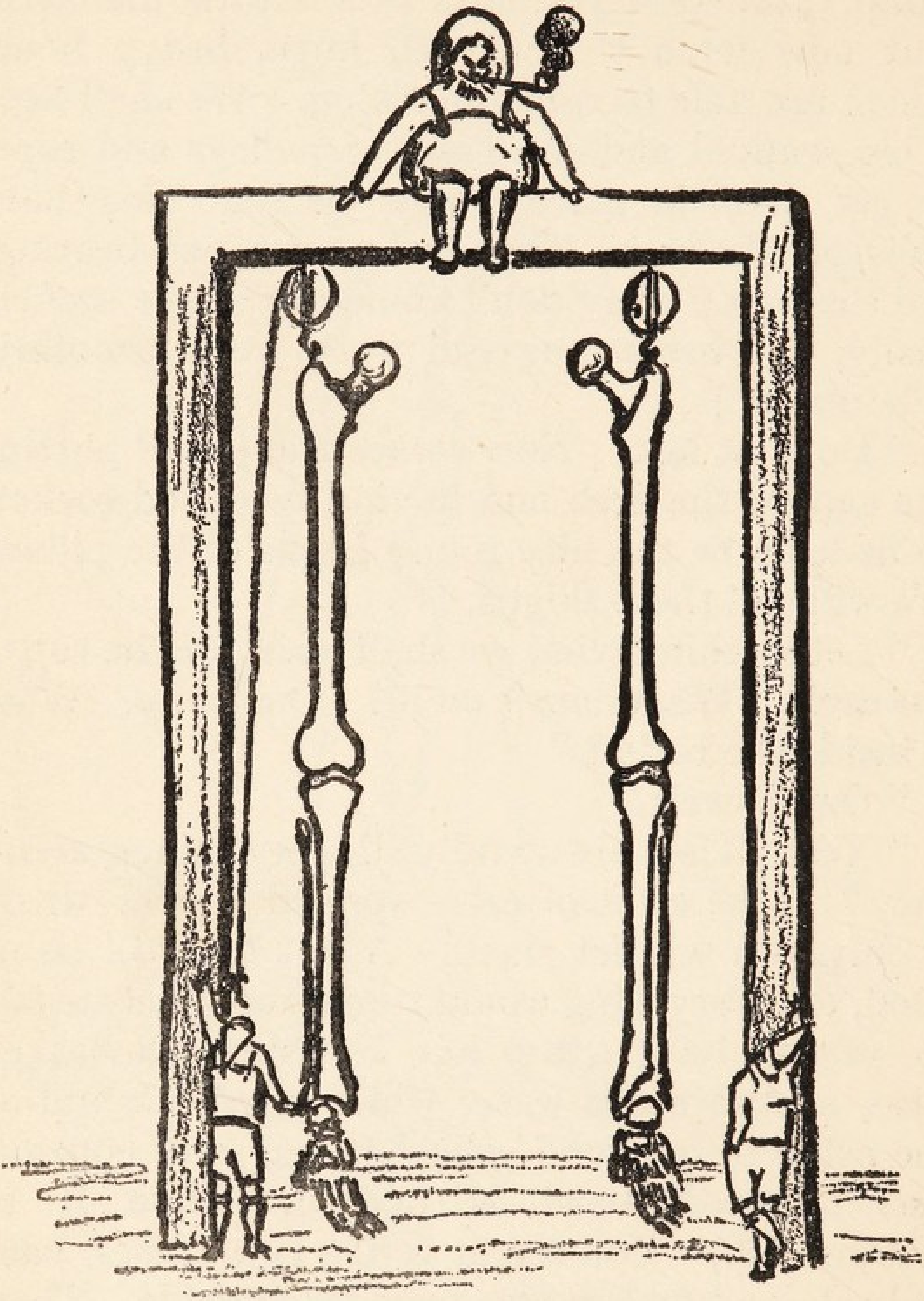
jump. I'll show you later how that is managed. But now fetch these great, huge, heavy bones which are able to carry anything. We shall need a big scaffold and some strong pulleys and ropes to get them in place. You see that they have balls on the top. That is because ball-bearings are the best; they don't come out of the sockets easily, and are strong and work very smoothly. (Picture 31.)

" Done at last. Now comes the job of putting the cap on the arch and having two good sockets to fit it on to the nice round heads of the pillars. We will call these thighs.

" Let us think what we shall want for the top of our arch. What comes on it? Our body. What is inside the body?"

" Our bowels."

" Yes. They are awfully slippery things, aren't they? Like a lot of eels—sprawling everywhere if only you will let them. A flat top will be no good, for everything would tumble off (Picture 32), so we will have a top like a basin or a basket. Also, all the waste water which we drink and all the ashes of our food collect there, so of course a basket-shaped bowl is needed. Here it is. (Picture 33.) You see, it is like two arches, back to back, and arched also from side to side. There is lots of give everywhere, so that it will be almost impossible to crush it. The wedge you see is there to fit the spine upon. That will make the keystone for our arch. This bony basket will be



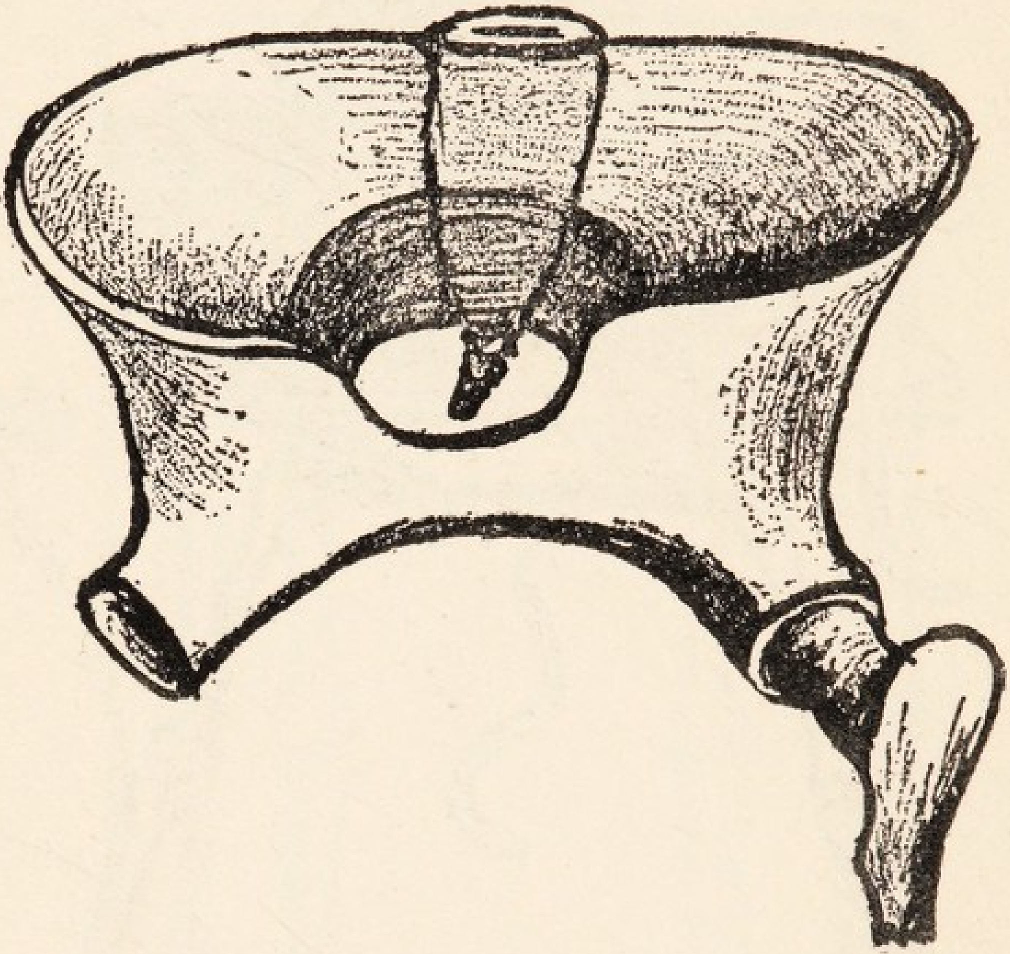
31. The lower limb is now complete.

closed below, and being the lowest part has to hold the cesspools of useless water and the

32. "A flat top will be no good."

garbage until the time comes when it is convenient for us to empty them. The cap of the arch closes the basket on the top. Now we will hoist the whole into place. There is the big arch complete. (Picture 34.) The rigging on the right arch shows how it is braced up.

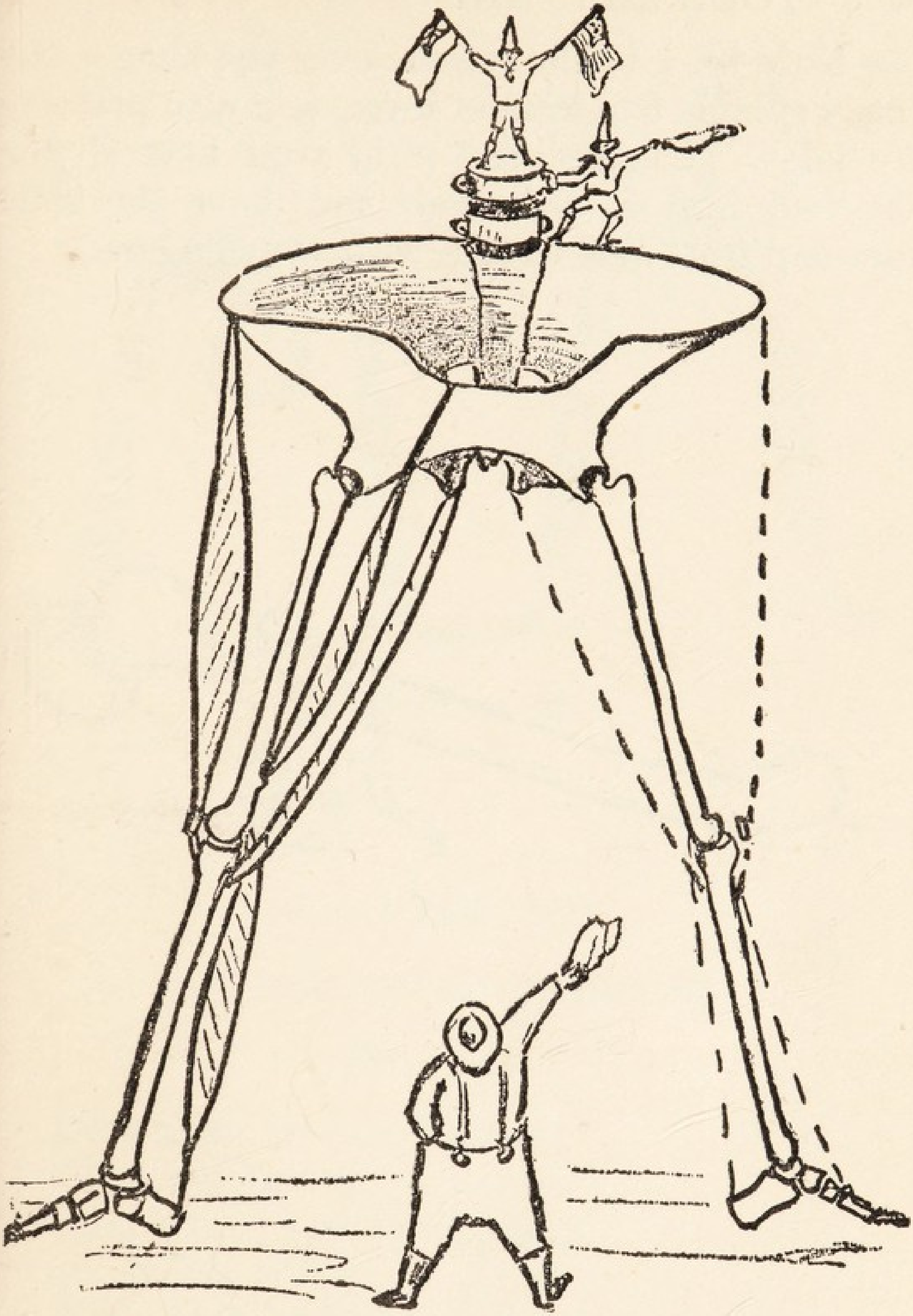
"Now we can build up the spine to carry our head office. Won't it be a fine lookout for seeing around! Also up there you can suck in all the



33. The basin that makes the arch.

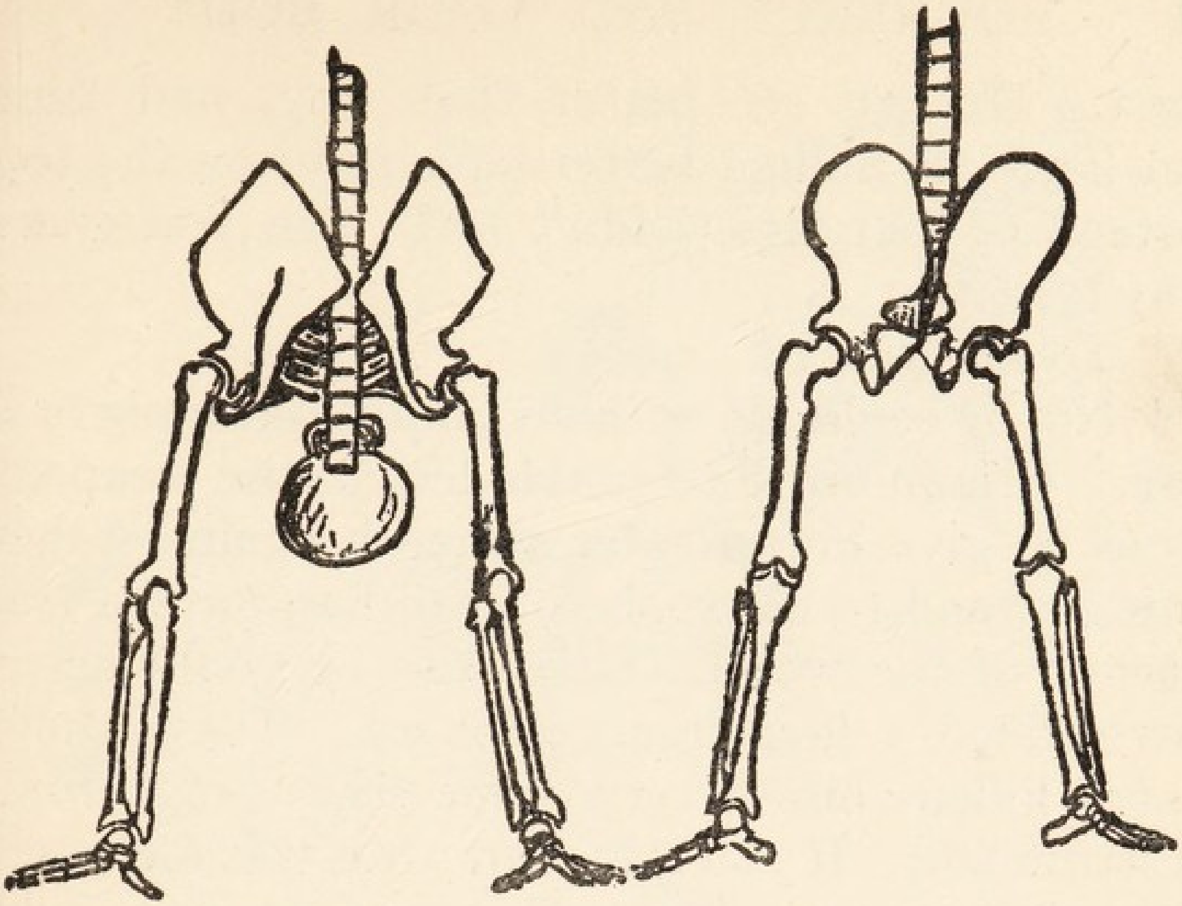
fresh air you need. We have put a rubber buffer between each block of the spine, as I told you before. Also you can see by the picture how the body can stand on tiptoe; that is really how we lift up the body and carry it forward when we walk.

"On the right leg I have put in the muscles to show you how they are tied to the bones. (Picture 34.) I have not put them all in. But you see how they bend the leg and kick it out again.



34. The arch complete with the basin on the top.

The little bone in the muscle over the knee is the knee-cap. It is a kind of lever, and also protects the joint. You can feel it in your knee if you put your heel on this chair and move the little knee-cap from side to side with your fingers."



35. Heads and tails.

CHAPTER VII

THE FRAMEWORK (*continued*)

The Arm

"Legs again to-day, isn't it?"

"No, arms, father."

"Same thing, just front legs."

"Oh, father!"

"Well, look at this picture of my bones—standing on my hands and feet. (Picture 35.) You see how like the arms and their girdle are to the legs and their girdle. Man must stand erect. He can see better that way, and turn quicker. So he had better have arms on the top instead of four legs, hadn't he? Can you guess why?"

"To eat with?"

"No, he could eat without hands, like a pig or a dog. It is in order to enable him to use weapons so as to give him greater strength against other animals, and to use tools so as to become the real master of the world. Otherwise he could never have killed a lion or an elephant. They would have killed him every time they saw him. (Picture 36.) If you lose your arms it is far worse than losing your legs. You cannot put your clothes on or feed yourself. A girl lives near here who was born without any arms, and though it took her years to learn she can now thread her needle and sew beautifully with her toes. You couldn't do it if you tried, could you?"

"No."

"Why not? Because different governing cells in the brain machine have to be educated—even new thinking-cells, and yours are not so educated.

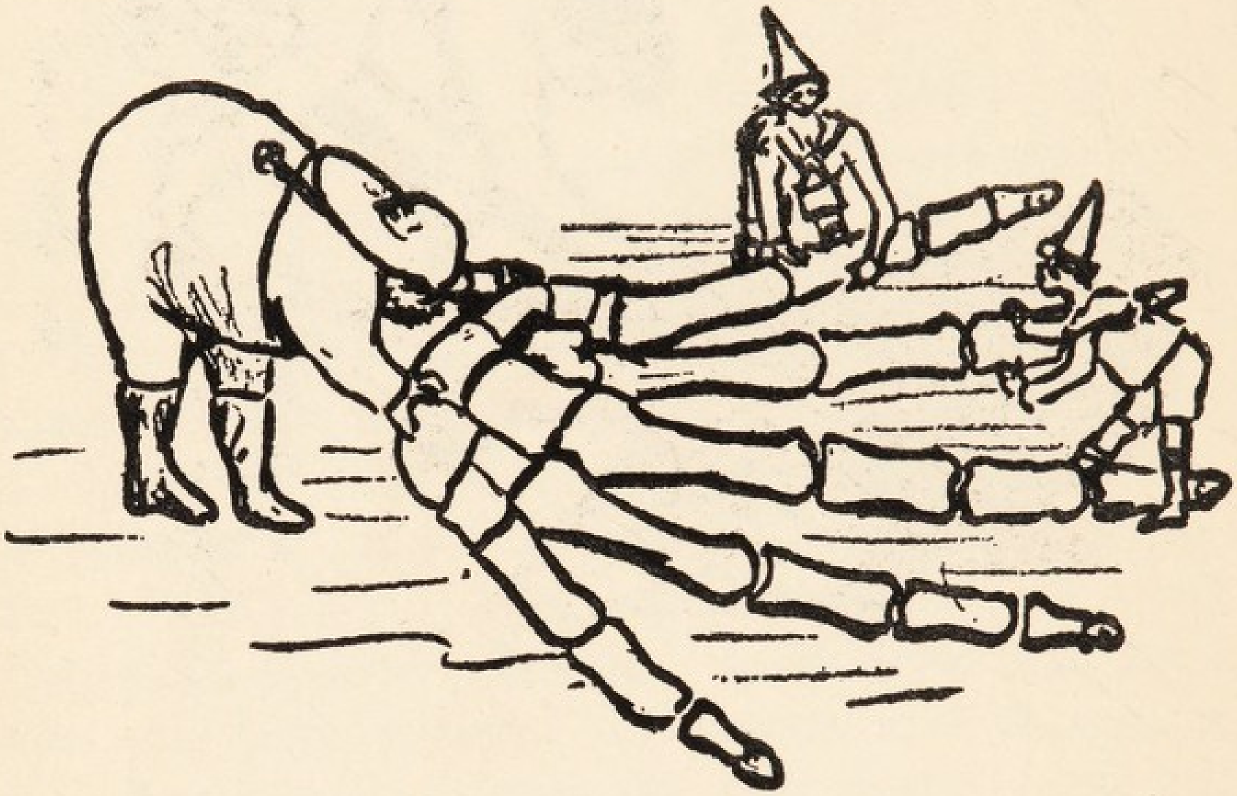
"Just as the body sits in the basin on the top of the legs with the spine up the back, so the arms hang from a cap on the top of the body.

"Now we will take the same number of bones as we took for the foot, and lay them out as they ought to be to hold instead of to walk. Now you see we have got the hand laid out. Isn't it like

36. Man as a " crawler."

Man with " arms."

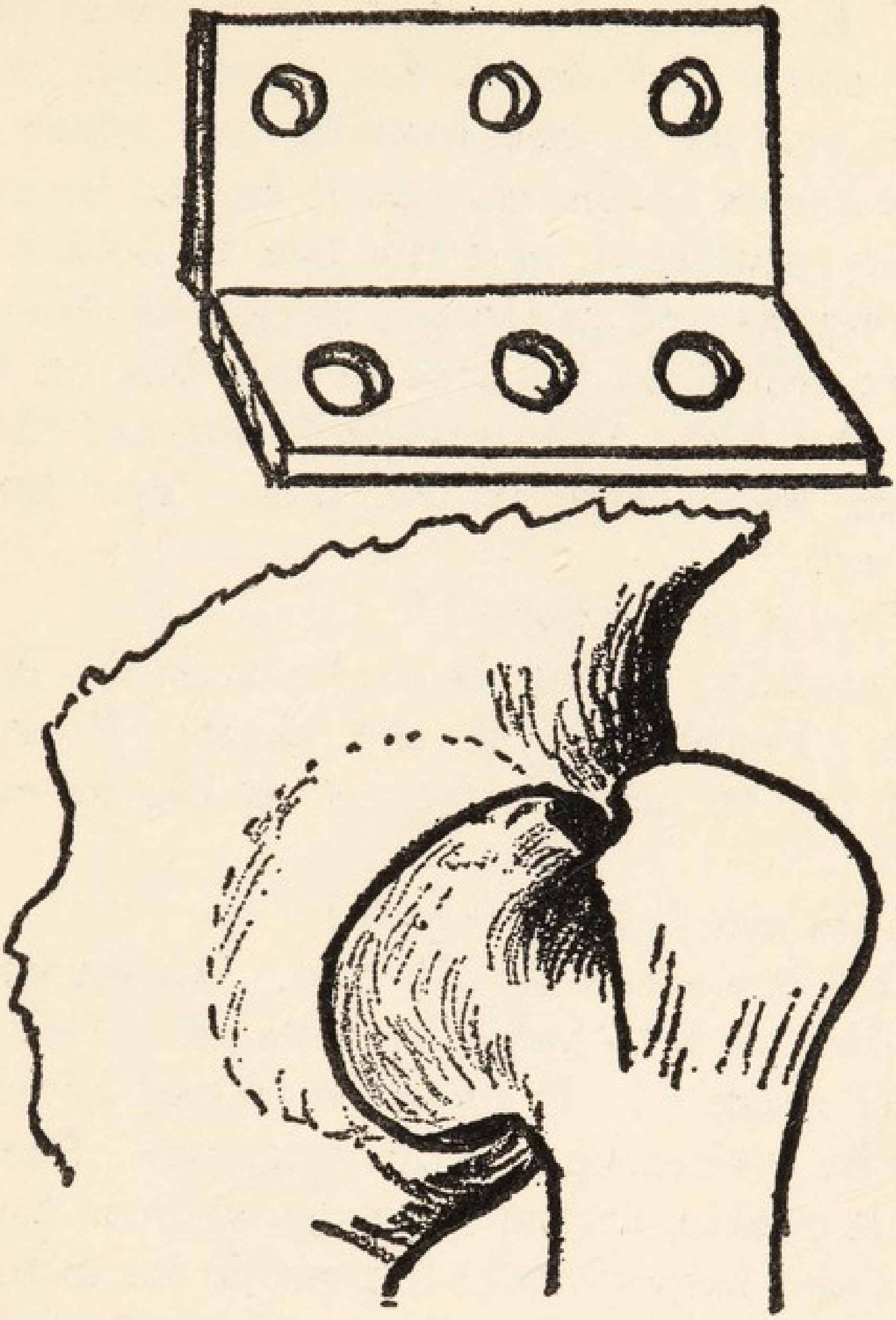
the foot? (Picture 37.) Only we do not want a heel in the hand to stand on, so those bones have grown quite small.



37. "Isn't it like the foot?"

"Now for the arm. Get two bones like the leg, and we will lash them together in the same way as before, except that we will let them turn round on one another, and not strap them so that they cannot move, like the bones of our leg. You fetch them, and I will carry the big bone of the upper arm. Isn't it exactly like the thigh-bone? Only as it has to twist about so much more than the thigh and leg we will not make the socket of the joint so deep. (Picture 38.)

"Now comes the arch or arm girdle. As you see, it is made up of the top bone of the chest,



38. A hinge joint (top) and the joint of the hip. The joint of the hip is a ball and socket. This is the strongest kind of joint to carry the weight of the body.

the collar-bones, and the shoulder-blades. But where will you hang the girdle up? It is absolutely necessary for our body to have a pump to keep driving the blood all over the body day and night, because in the blood are all the workers swimming to their work, in every corner of the body. If that pump breaks down once (as our motor sometimes does), for more than even a minute or two at the outside, the whole body dies and goes to pieces. So it has to be ever so carefully protected, and the box to hold it must be strong, as well as elastic, in case anything hits it. We will joint the ribs of this box on to the spine, and hang the arm girdle around the top. (Picture 39.) Here is the box. You know it quite well."

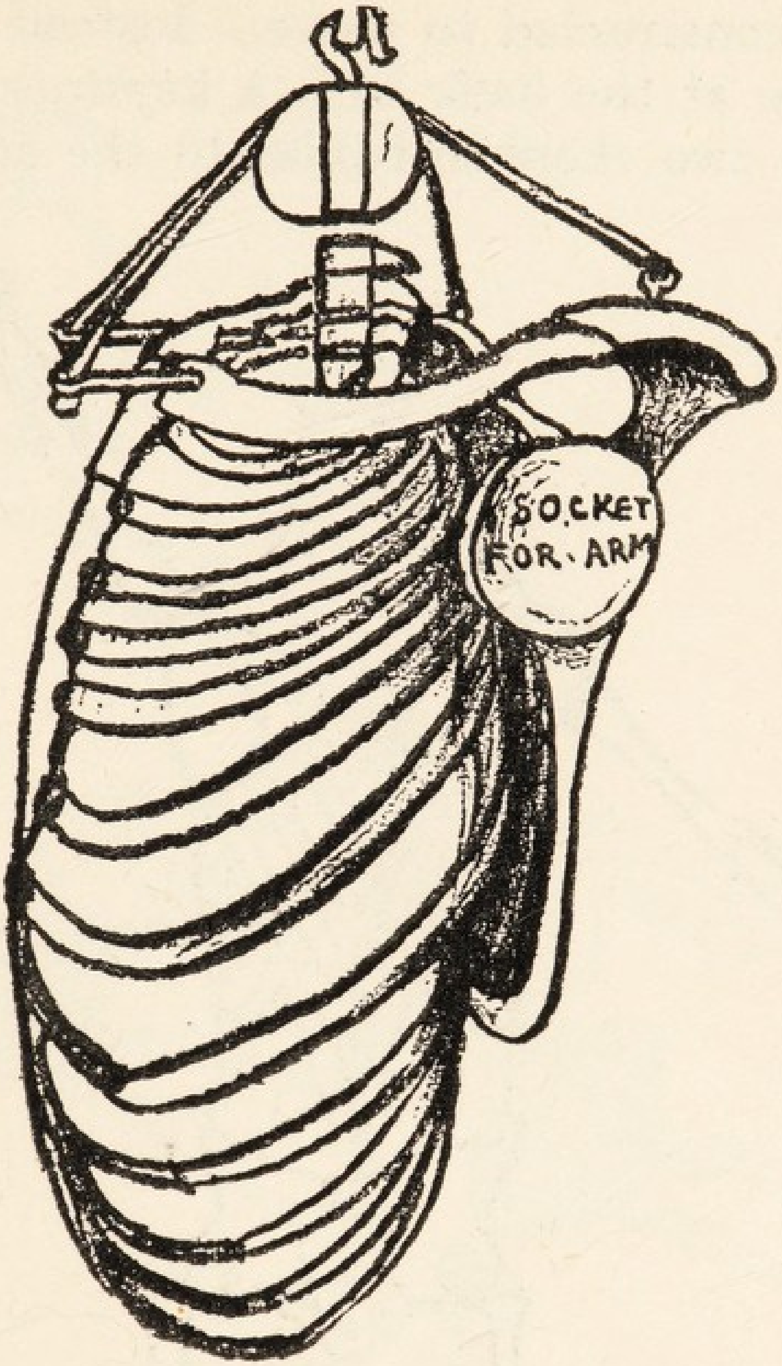
"Why, it is the chest!"

"Certainly; a box is a chest, and a chest is a box. People call it the chest. Every boy should try to make his chest as big as ever he can."

"What else is in the chest?"

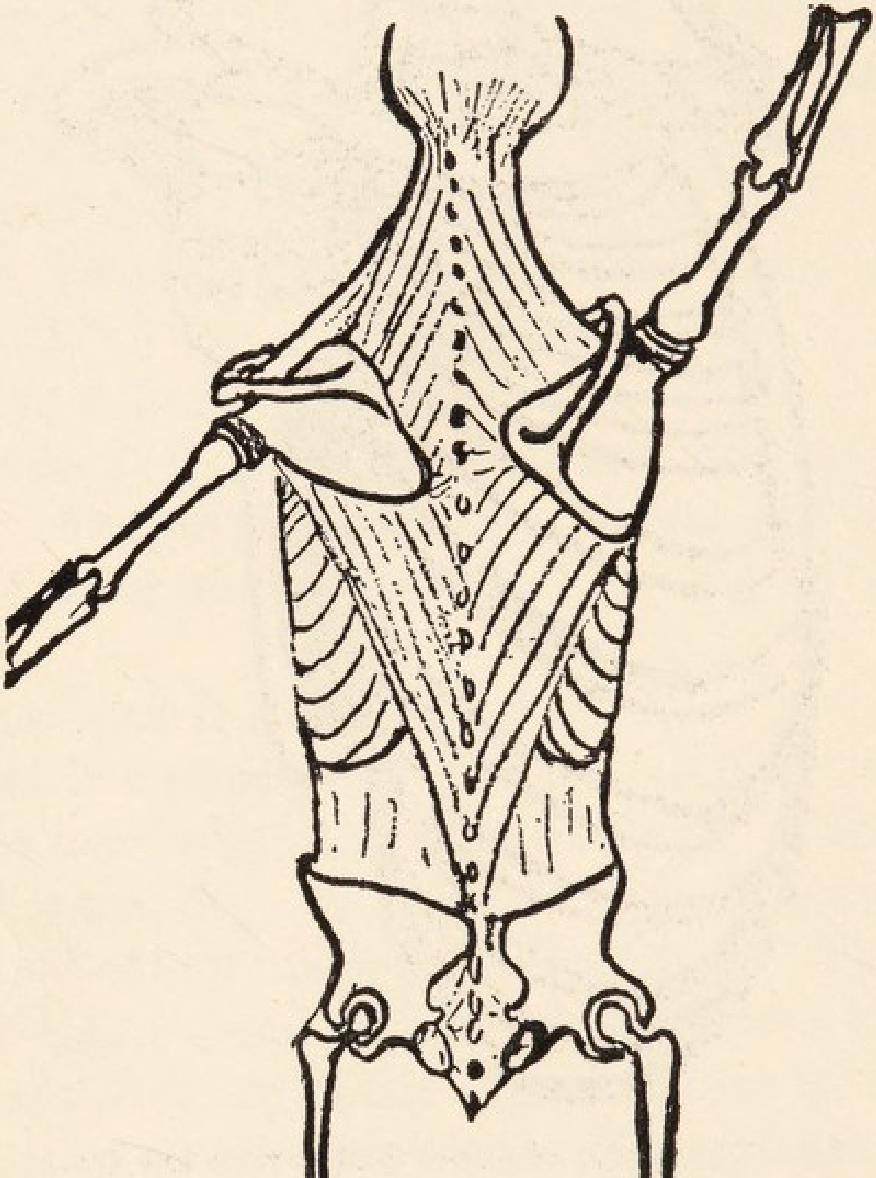
"That is a secret for later on. All we want the chest for now is to hang the arms on. This is how we will make it. It must be full of joints or it would be broken up in a few minutes. The joints make it elastic, and so save shocks from breaking it, and also help to make it possible for us to move our arms in every direction. This picture shows it a little more clearly. Where the ribs of the box are fixed to the chest bone they all have elastic ends like rubber. You can call it gristle. You cannot break it by hitting it. It just bends and then comes back to the same shape.

"Don't forget that the wonderful thing about the arm is the way we can move it about and pull and push with it, and yet it so seldom gets out



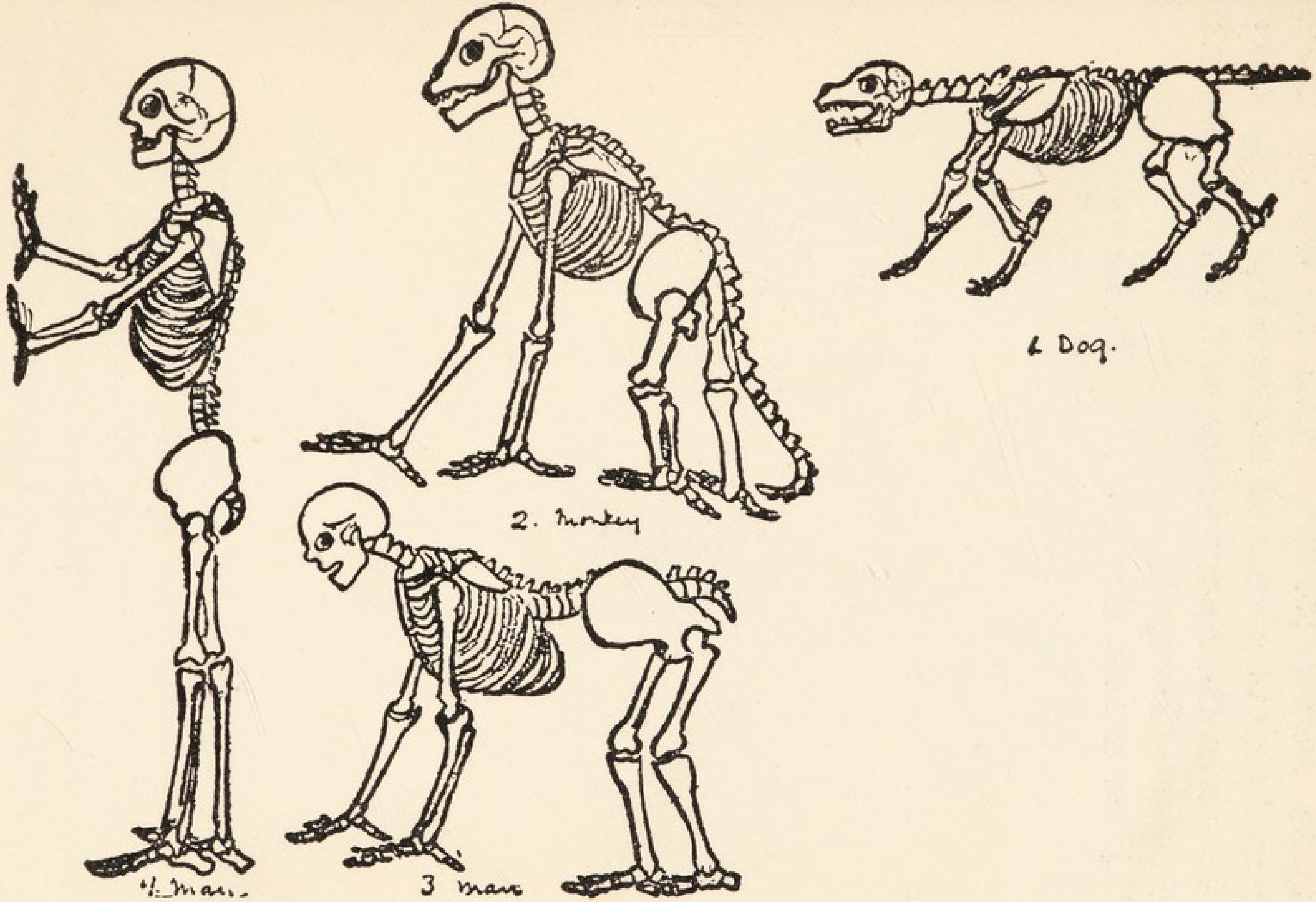
39. The girdle of bones that carries the arm.

of joint. Look at this knee-joint, for instance. It can move only one way. To be able to comb your back hair, or scratch the middle of your back, or circle through your hands on the rings in the gymnasium, or pitch a baseball, just think what a joint you need. To make it strong and still more movable, even the socket itself is very cleverly constructed to move. Instead of fixing the girdle at the back with a keystone, we will sling the two shoulder-blades to the spine with



40. The cleverest joint in the body.

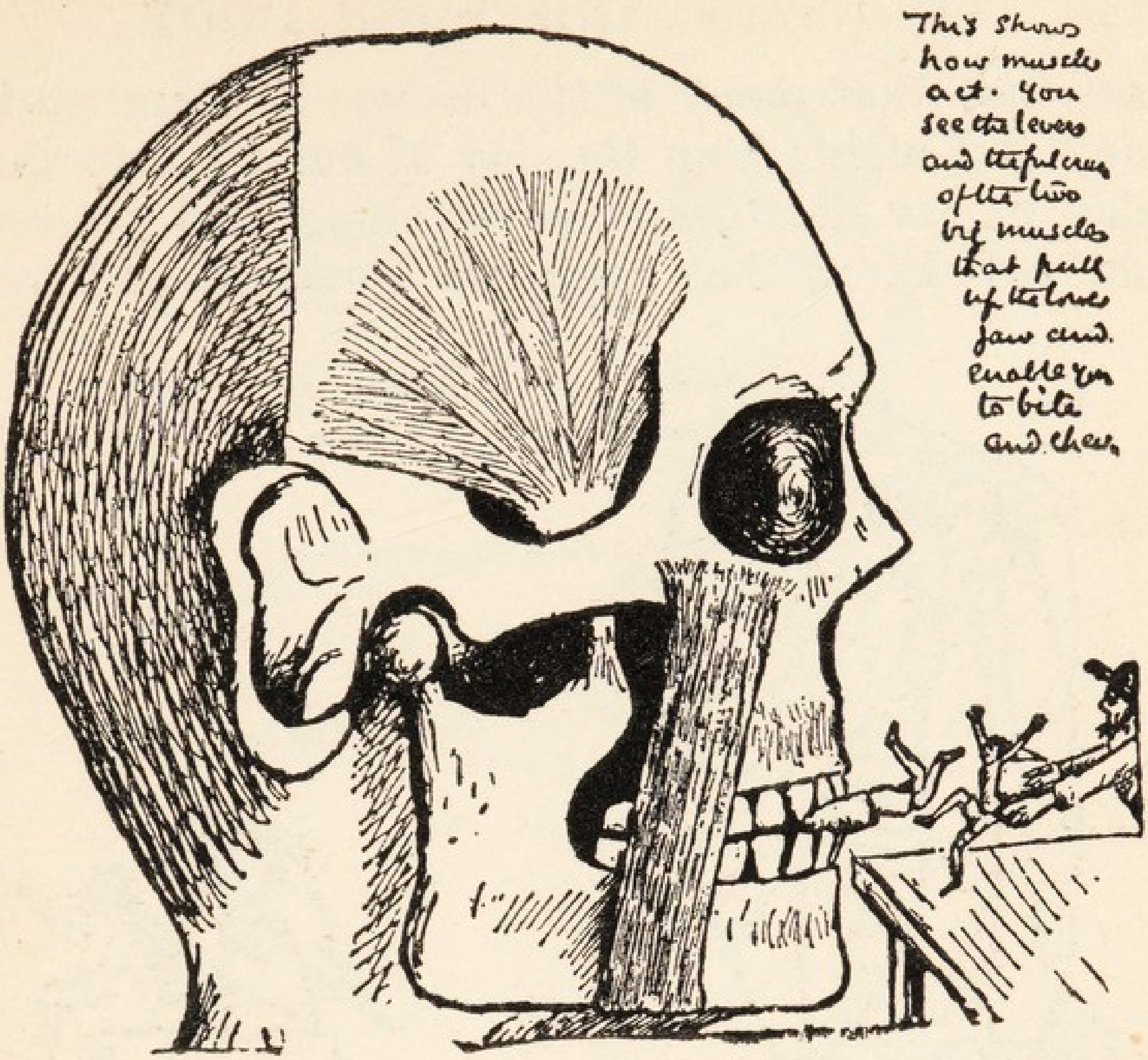
strong muscles. Thus the bone-cap of the arm always presses straight in, or pulls straight out of the socket—never sideways. This prevents the shoulder from going out of joint, even though the socket has to be nearly flat, so as to allow the



41. The same kind of frame, fitted for a dog, a monkey, and a man.

arm to swing around. This is one of those especially neat pieces of engineering in the body which show the clever design of it (Picture 40) and the cleverer Designer.

"Here endeth the arm!" (Picture 41.)

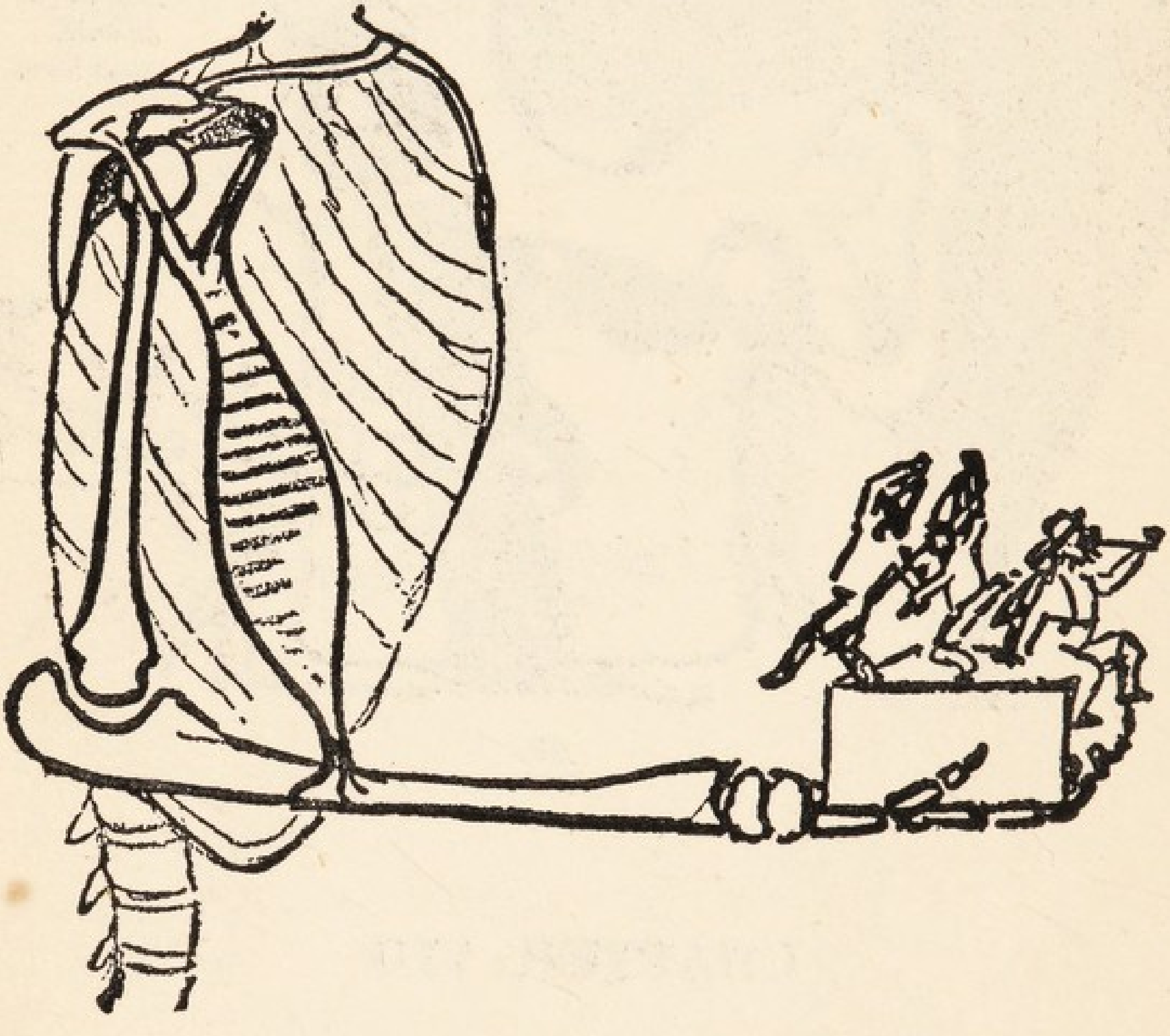


42.

CHAPTER VIII

THE MOTORS

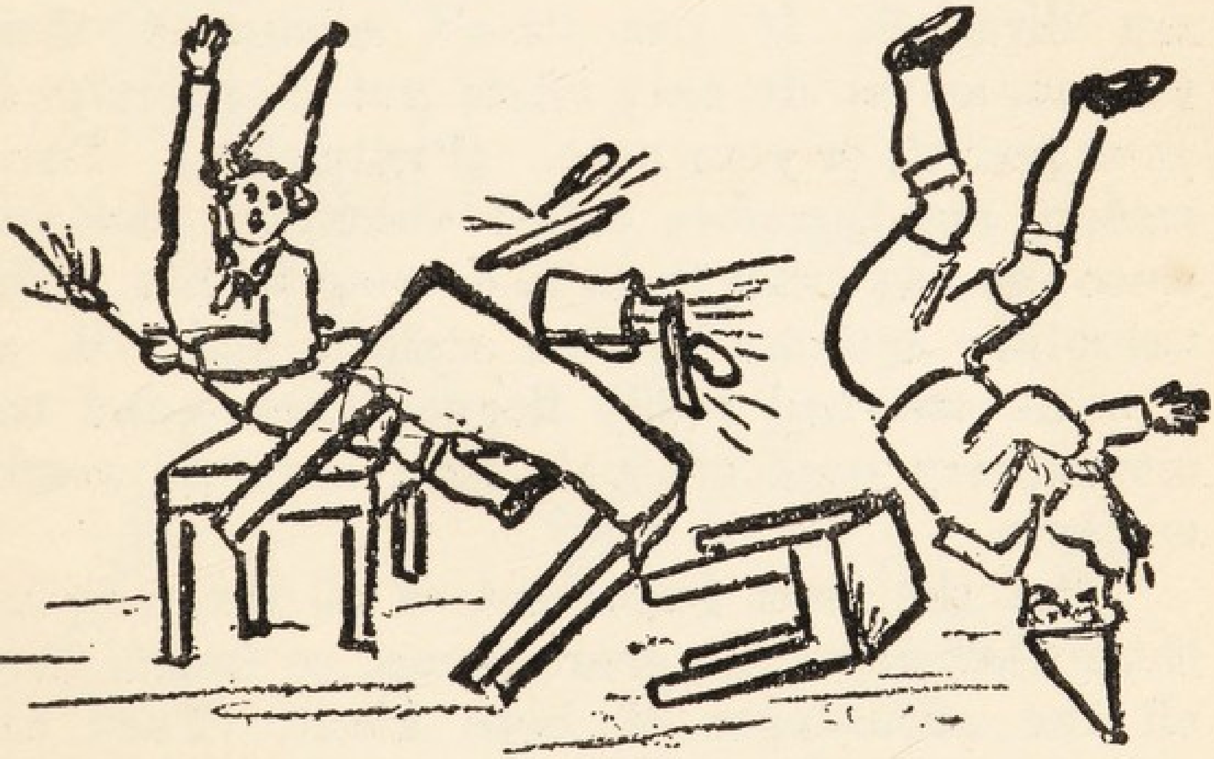
"THE world thinks a lot of itself nowadays because of the way we can travel about so nicely and so quickly. But you remember the trapeze men, and the bareback riders, and the 'bronco-busters' at the circus, don't you? You will soon see that our bodies are still by far the most wonderful 'moving' machines on earth—so marvellous are they that many of the motors in them work day and night, from the day of our birth to the day of our death, and never stop; and yet we do not know that they are working, and we



43. Our biceps (two heads) is awfully strong.

cannot stop them, and we cannot order them about. They repair themselves while they go on working, and though the force which works them is probably very much the same as the force that we call electricity, there is never any spark-plug trouble, or any short-circuiting

The motors controlled.

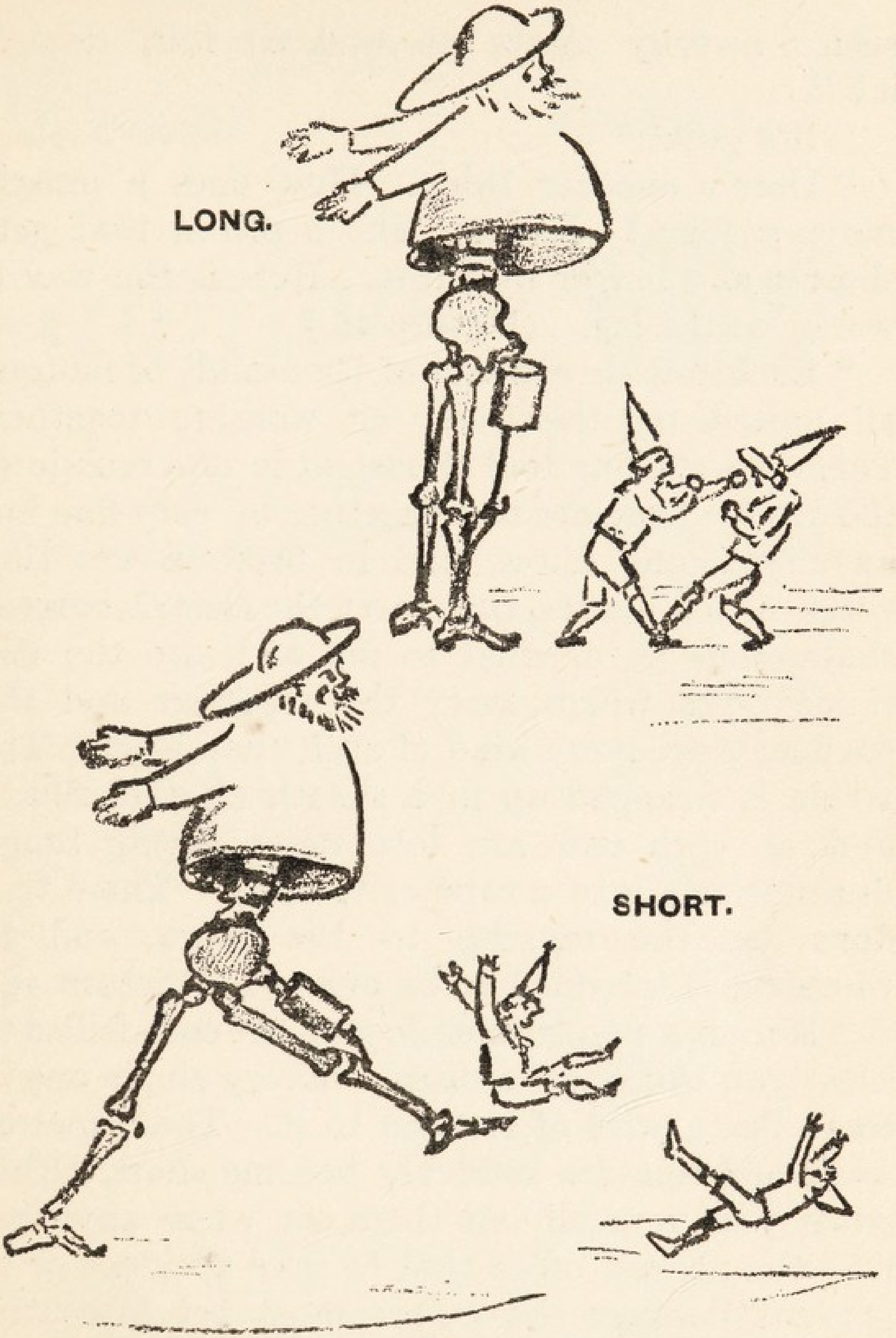


44. The motors uncontrolled.

that stops the gears from working one single moment.

"The old Romans called these motors 'muscles.' There is one kind which we cannot control, and fortunate for us it is, for we get tired, and they never do. They arrange to rest while they work. They are called involuntary muscles; but we *have* to control the largest, the quickest, and the most powerful, and so, like slaves, they soon get tired. For example, you want—that is, it is your wish—to pick up a spoon and scoop up some porridge from your plate, and carry it to your mouth. Framework alone cannot do that—it must have a motor to move the joints, such as the fingers, or elbow, and move them as they are directed. If you didn't command these motors, as you do, they might put the porridge in your pocket, or your nose. (Picture 44.) These motors are therefore called voluntary muscles, since you can order them to do your wishes. The voluntary muscles are all striped and red, as if some one had really flogged them—and the involuntary ones are pale, and have no marks on them.

"But the most important of all the muscles, those that drive the great pump, or heart, have all the advantages of both kinds. They are red and striped; and yet, since they need no control from us, they never get tired, while they are both strong and quick to act. That



45. Showing how the great muscle of the thigh acts by lengthening and shortening.

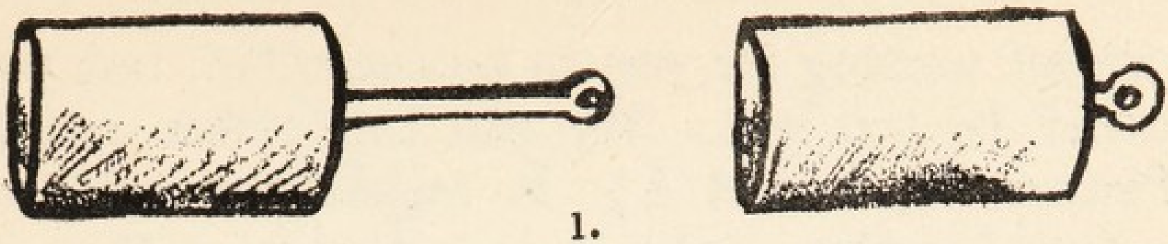
seems awfully clever as well as fair, doesn't it?"

"It's great."

"Here's another thing. How does a muscle move a joint? Exactly like a piston that gets shorter and longer by turns. Here is the way it works on the leg. (Picture 45.)

"Each muscle consists of thousands of motors, all united together, and all working together. There are six hundred thousand in one muscle of the arm. They are tied together by very fine but awfully strong fibres, and in between are tiny wires, called nerves, that carry the electric current that orders them what to do, and also the still tinier pipes which carry the repairers and the feeders, with every kind of stuff they need. The whole is wrapped up in a sheath of stout fibres, and at each end are lots more strong tough fibres woven into a rope or tendon. These tendons tie the muscles to the bones, and to whatever is intended to be moved. (Picture 46.)

"Here is a striped muscle with the ends frilled to show you the single motors. Every single one of these has a wire of its own to it. These motors work and muscles suddenly become short, either when you yourself tell them, or when anything tells the nearest office that to save accident or to prevent damage the motor must act instantly. There are special cells always on duty in local offices which tell them to shorten up at once,



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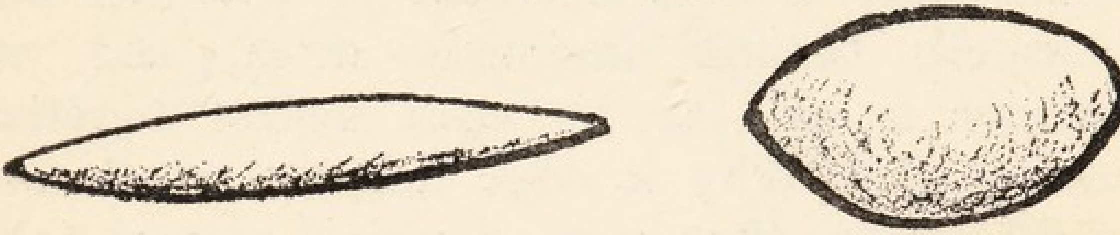

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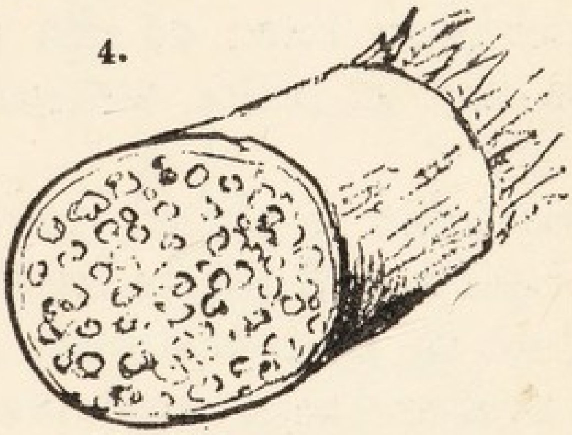


5.

46. The real motors are cells like these :

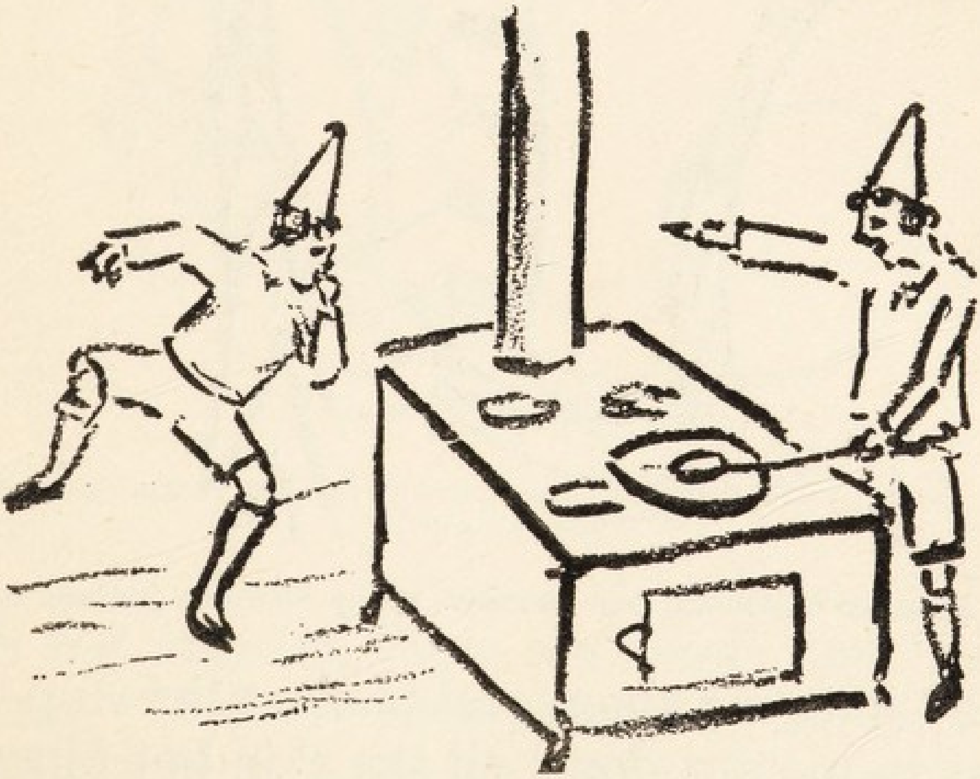
1. Piston full length open; piston closed or contracted.
2. Voluntary muscles at rest and contracted by the will.
3. Involuntary muscles at rest and contracted without our knowing it.
4. Muscles in sheath partly unravelled to show single cells.
5. Cross-section of the muscle and of the cells in it.

without waiting for you to be consulted, lest you should be too late. We call this reflex action. (Picture 47, *a* and *b*.) It means the same as 'return' action, only it is automatic—that is, does the thing itself without waiting for orders—and instantaneously. When you make a hole in water, or punch the bag, the hole instantly fills up by itself—that is automatic.

"The way a muscle works is that the long motor-cells become instantly short, and pull whatever is tied to its ends nearer together. (Picture 42.) Why it does this, no one knows. We only know that some chemical change takes place, that heat is given off, and that, as an ordinary piece of wool underwear does when boiled, it does get shorter. Moreover, this is the way in which nine-tenths of the heat of our body is made. That is the reason why when we work very hard or run a race and so many motors are at work we get hot and sweat all over.

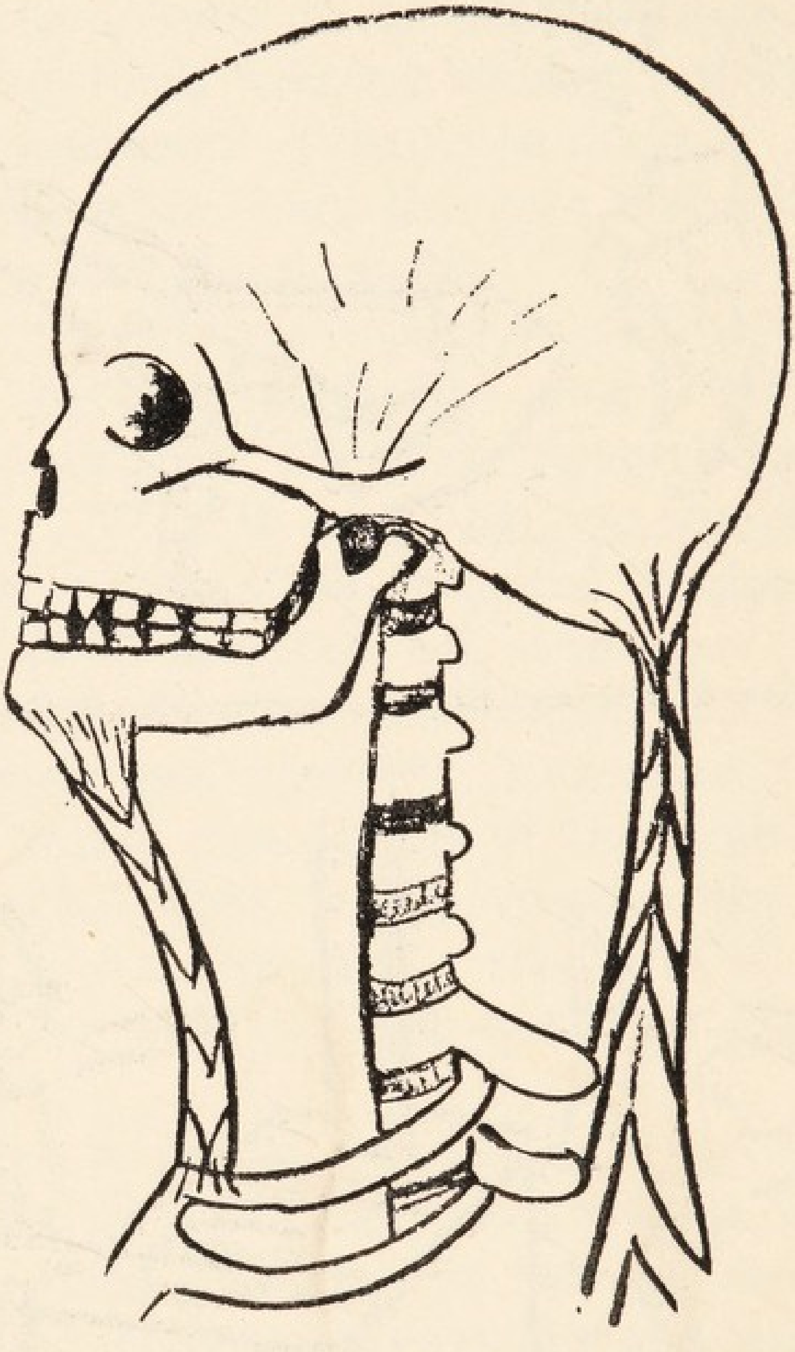
"The joint is pulled quickly one way or the other because all joints have one muscle on each side, just to keep the joint in balance and keep things taut and ready to move either way instantly, and so avoid jerks. (Pictures 48, 49.) This is called 'muscle tone.' On cold days we feel it best (*i.e.*, are high-strung), because the brain makes all the muscles work a little more in order to keep us warm. If we are still too cold, they

47. *a.* Messages to and from the brain and muscles fly like lightning.



47. *b.* Mother nature has to teach some folk by experience a Christian's finger will burn as quick as a sinner's.

work harder, and we start 'shivering.' This is an automatic warning to central to turn on more

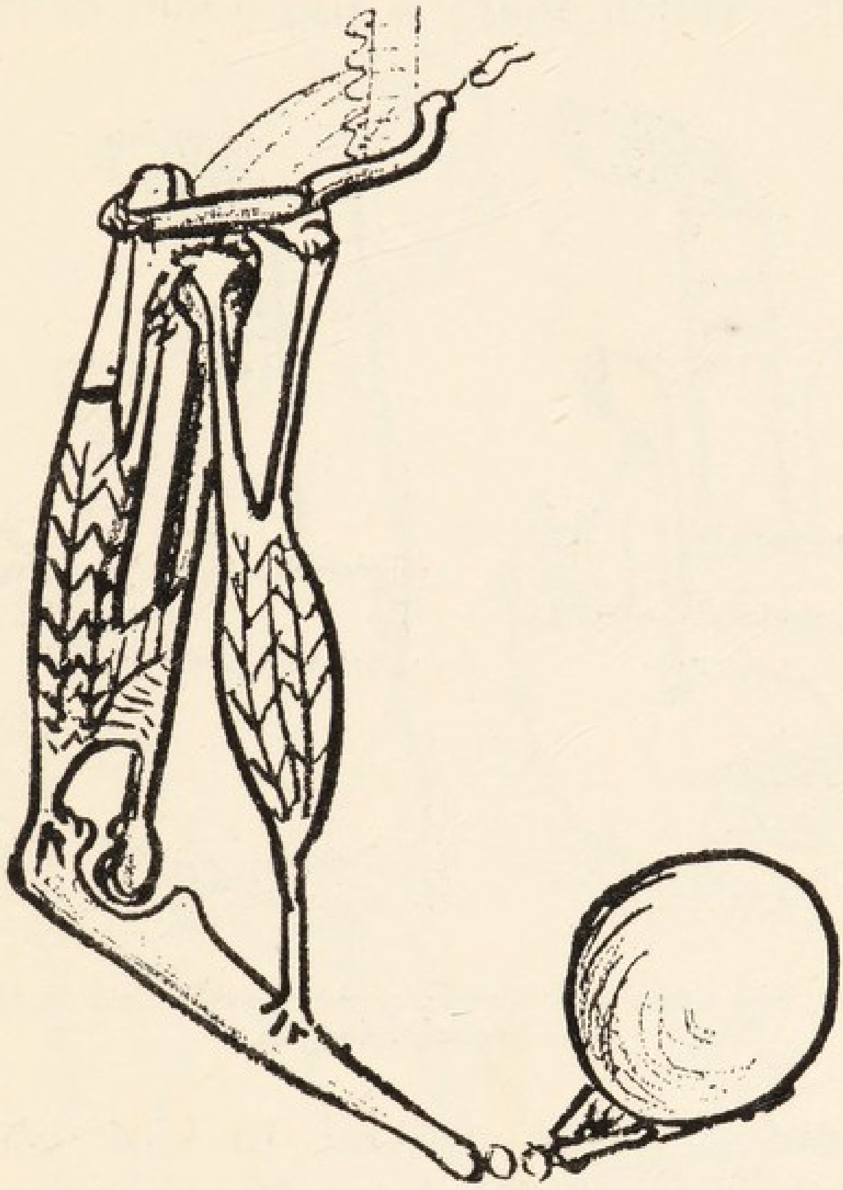


48. Muscles balancing one another, ready to make instant moves.

heat by jumping about and to close the stop-cocks —that is, narrow down all the skin hot-pipes and save heat. That is why we get pale and blue when cold."

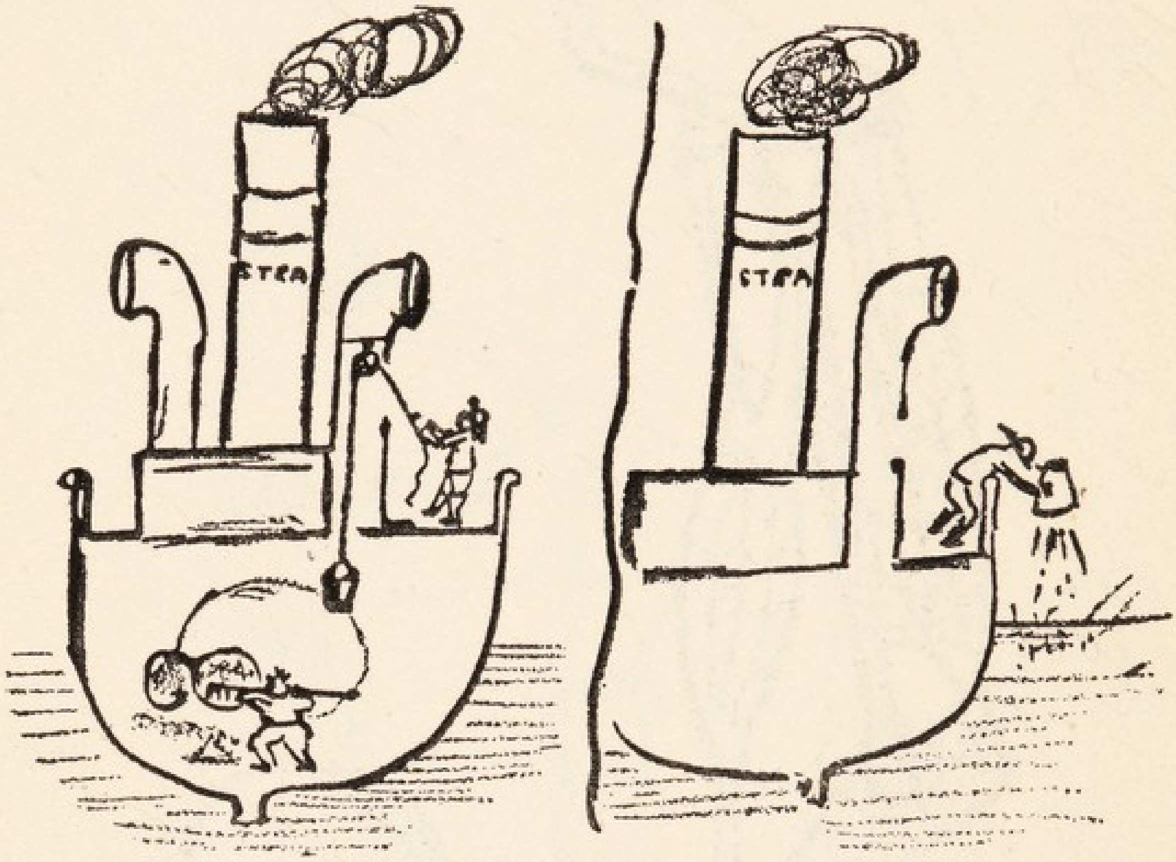
" How many of these motors are there ? "

" Millions in all ; but of groups of them, that is,



49. Muscles balancing the elbow joint. Triceps three heads. Biceps two heads.

whole big muscles, there are about four hundred and ten. It is a whole army of motor-tractors. All these motors must burn something, naturally ; and the stuff that they use is like sugar and water, and is called glucose. The pipes bring it to them in the blood stream. As soon as it is burned something is left behind like the soot or black carbon of oil, or the ashes of coal. It is mostly acid stuff. When there is too much of that the

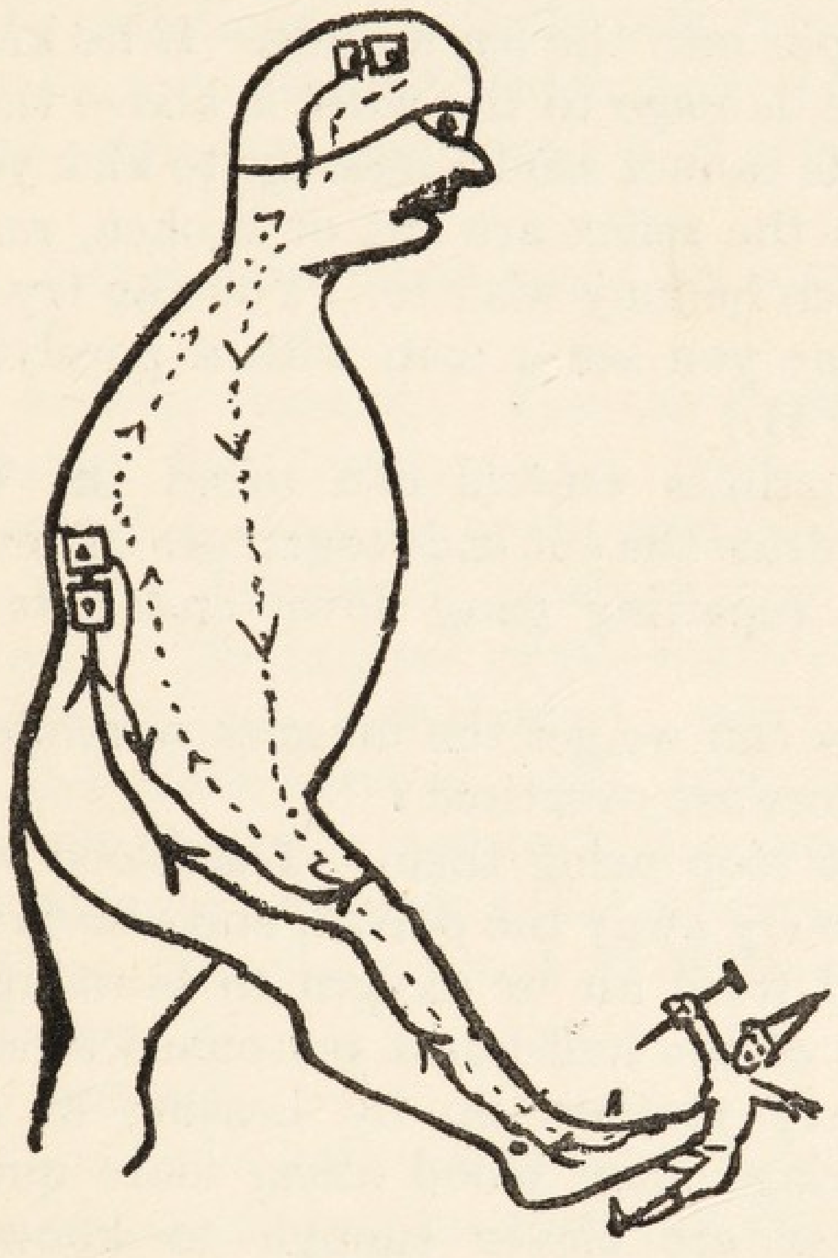


50. Cleaning out ashes and throwing them overboard or the engine will become clogged.

muscle-motor warns central to look out or it will break down. (Picture 50.) Just so it is the acid from smoke that kills the flowers in cities."

"But how does the muscle do that?"

"It sends a message to the central office, which we call 'having a tired feeling.' A tired leg is only a leg from which the ashes have not been emptied, and there is too little fuel. If we neglect the warning we get ' cramps ' ; which means that the muscles are all staying contracted and giving you a very nasty pain as well, so that you squeal



51. A reflex act—local office is giving orders without taking time to appeal to central ; " works while we sleep."

out and pay better attention to their warning the next time. If the wires carrying the orders get cut or crushed, the motors are out of commission, unless the damage is above a local office in the spine where the 'reflex' orders are taken care of."

"Can you tell where the break is?"

"Yes. If it is a man with a paralyzed leg, stick a pin into the leg muscle. If he kicks you, then the damage to the wires is above the reflex-box. He cannot send a message to kick you if the wires to the reflex are cut or broken, no matter how much he may wish to. You can try this the next time you see a man with a paralyzed leg! (Picture 51.)

"Sometimes central can mend the wires, if doctors draw the cut ends together. Then central sends a repairing gang down and puts in new wires.

"How can we get the muscles running again if the motors are overtired?"

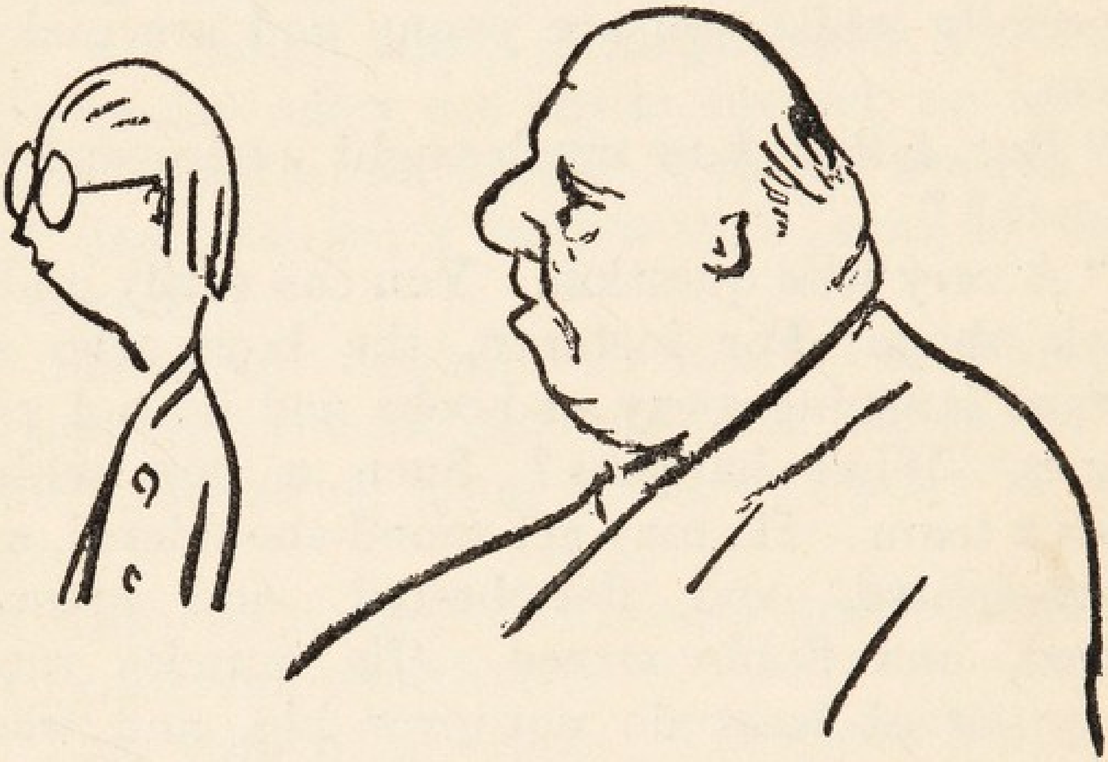
"Just stop using them. The blood will then slowly carry away the poison, and also bring fresh fuel and fresh air or oxygen to burn up all the remains of the half-burnt poisonous ashes. You can hurry matters up by heating or rubbing. That brings more blood along more quickly, as the pipes are clever enough to know what's wanted, and to make themselves larger at once. But don't forget that you can overwork the motors until you spoil them for good and all. For example, before there were any typewriters lots of clerks overworked their hands by holding pens and writing so long that they got writer's cramp, or palsy. They never again could get quite well. Our bodies accept no excuses. They never fail to punish us if we ill-use them, whether we do it ignorantly or not. 'Watch your step,' shouts the policeman; while doctors, which really means wise men, say: 'Watch your bodies'—especially while you are young and are making them."

"But, father, how much ought we to work the motors?"

"A very wise question. You can easily underwork them. For instance, the boys who are always mugging away at books and do not play games. What happens? Such a boy seldom joins a team. He may get round-shouldered, and short-sighted, and flat-chested, and spindle-legged, and flabby-armed. His muscles waste away, or at least do not grow big, and when disease or accident overtakes him, he cannot resist it and dies. You have heard of Walter Camp's 'Daily Dozen'?"

"Yes, rather."

"Well, he had a splendid body and was a great athlete, and noticed how many people get lazy and careless about their bodies as they grow older. They are more eager about making money, and eating, and parties, and stuffy hot rooms. They neglect open-air exercise, and get fat and flabby, and nervous and bad-tempered, and break down and die young. (Picture 52, *a* and *b*.) So he taught them to spend time exercising their bodies, because they are the machines, without which we can do nothing at all, and have nothing at all. Man can't escape working for anything that is really worth having—just as the Bible says.



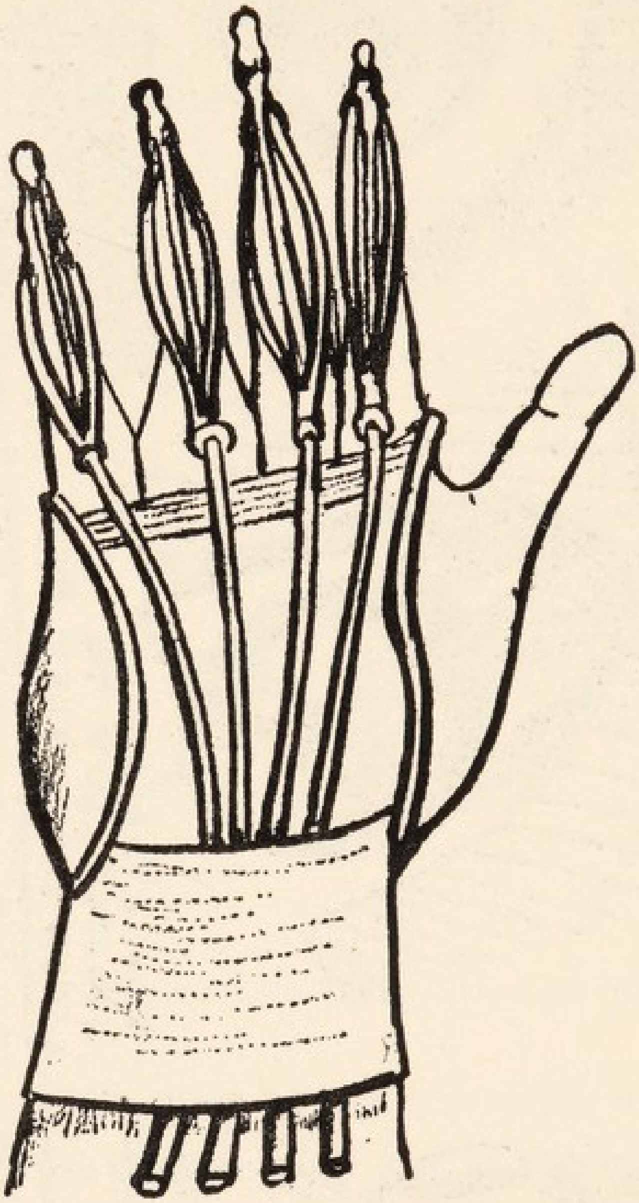
52. Under-exercised (*left*). Overfed (*right*).

"Now here are some motors with which we can roll our eyes around just as we wish. (Picture 53.) Inside the globe or eyeball are more muscles, for opening and closing the safety-shutters, which we call the pupil. It protects the delicate seeing film—central can't trust us to remember to do that without ever once failing. So these muscles are involuntary. We can't control them. This is central's way all over the body. Let us look at a few voluntary motors. Give me your hand.


THOSE THAT PULL IN STRAIGHT LINES ONLY.
TOP STRAIGHT MUSCLE CUT TO SHOW THOSE THAT ROLL
3 Straight Muscles Cut to show the Rollers
THE MUSCLES THAT MOVE THE EYES. THE MOST MARVELLOUS COMBINATION IN THE WORLD.

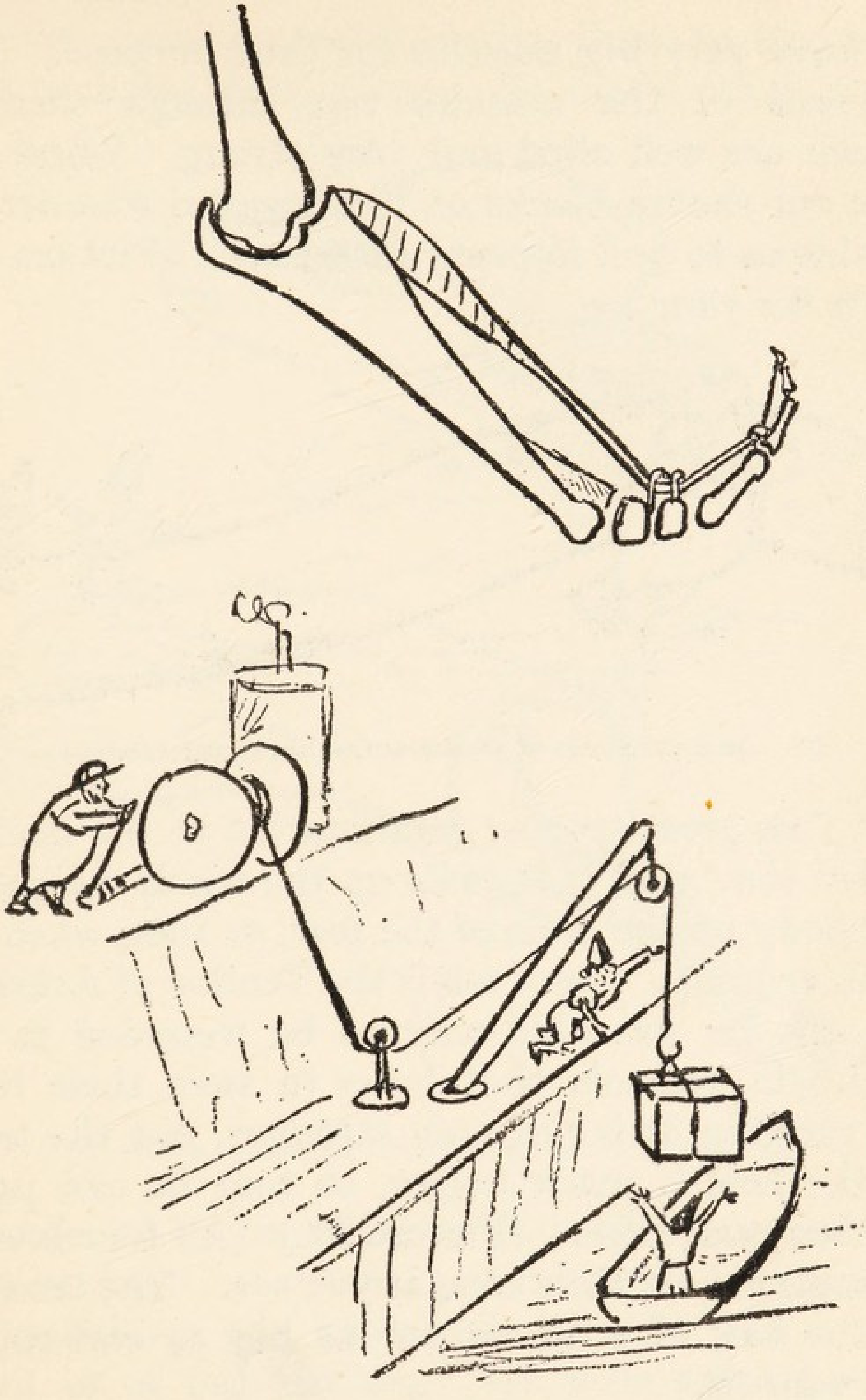
53.

You can easily feel the tendons in your wrists. Each finger has a tendon in front to bend or flex



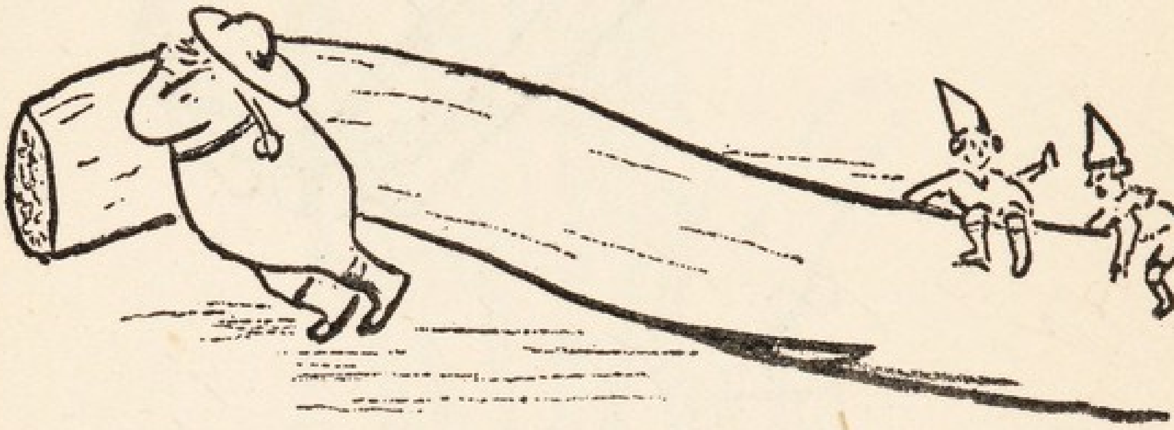
54. Showing the formation of the block arrangement in the fingers and wrist.

it, and one behind to extend or straighten it; and there are side motors to pull them sideways, and one to pull the thumb over and nip things, so that you can pick up a piece of money if you want to. (Picture 54.) Some races of people are said



55. Snatch-blocks changing direction of the pull.

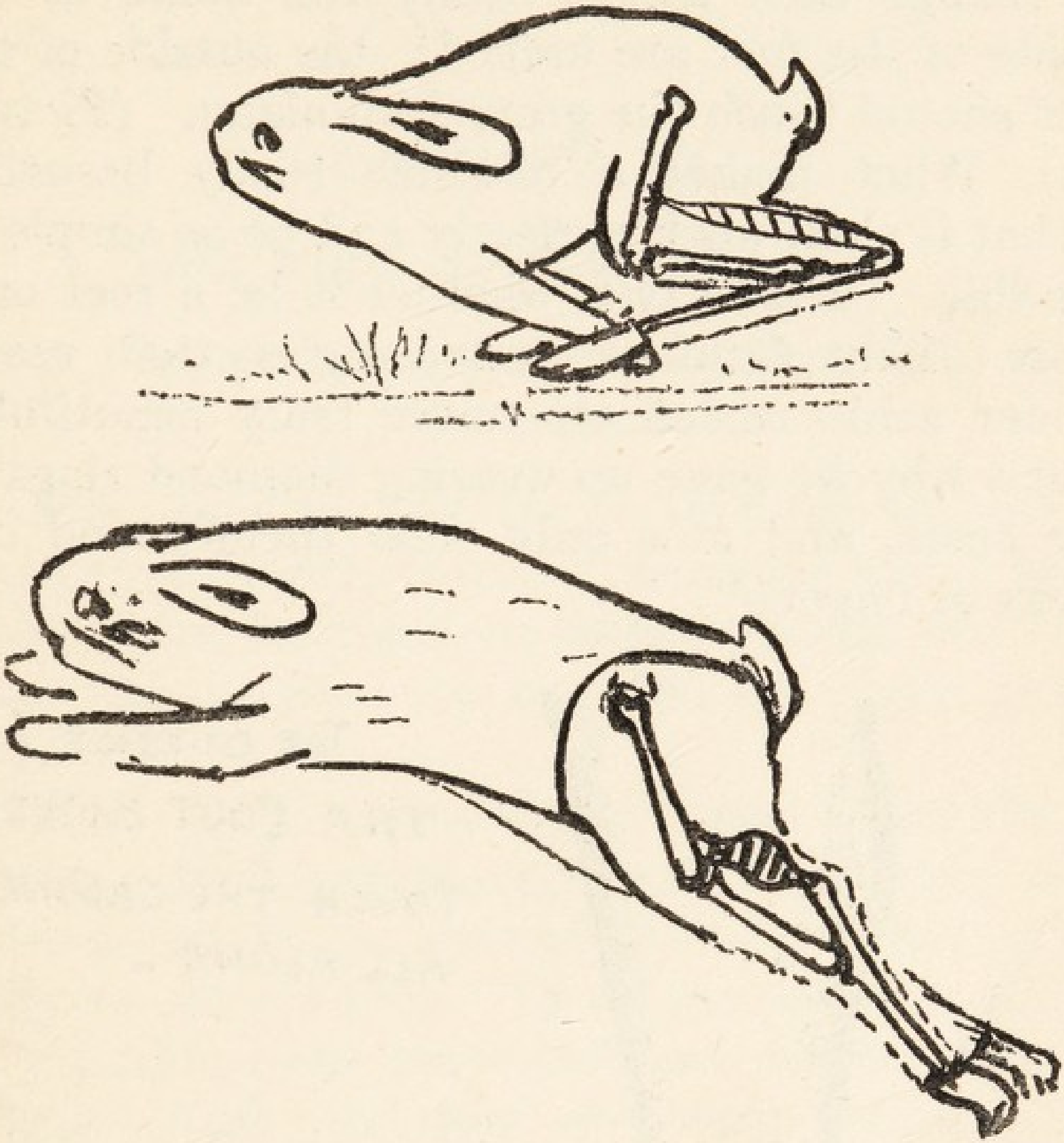
to have very big muscles for that purpose. The tendons of the muscles run through sheaths, which are well oiled and very strong. These act like our snatch-blocks on the hospital steamer, to enable us to pull in every direction. (Picture 55.) Now for your leg.



56. Some tendons of whales are as heavy as cart-ropes.

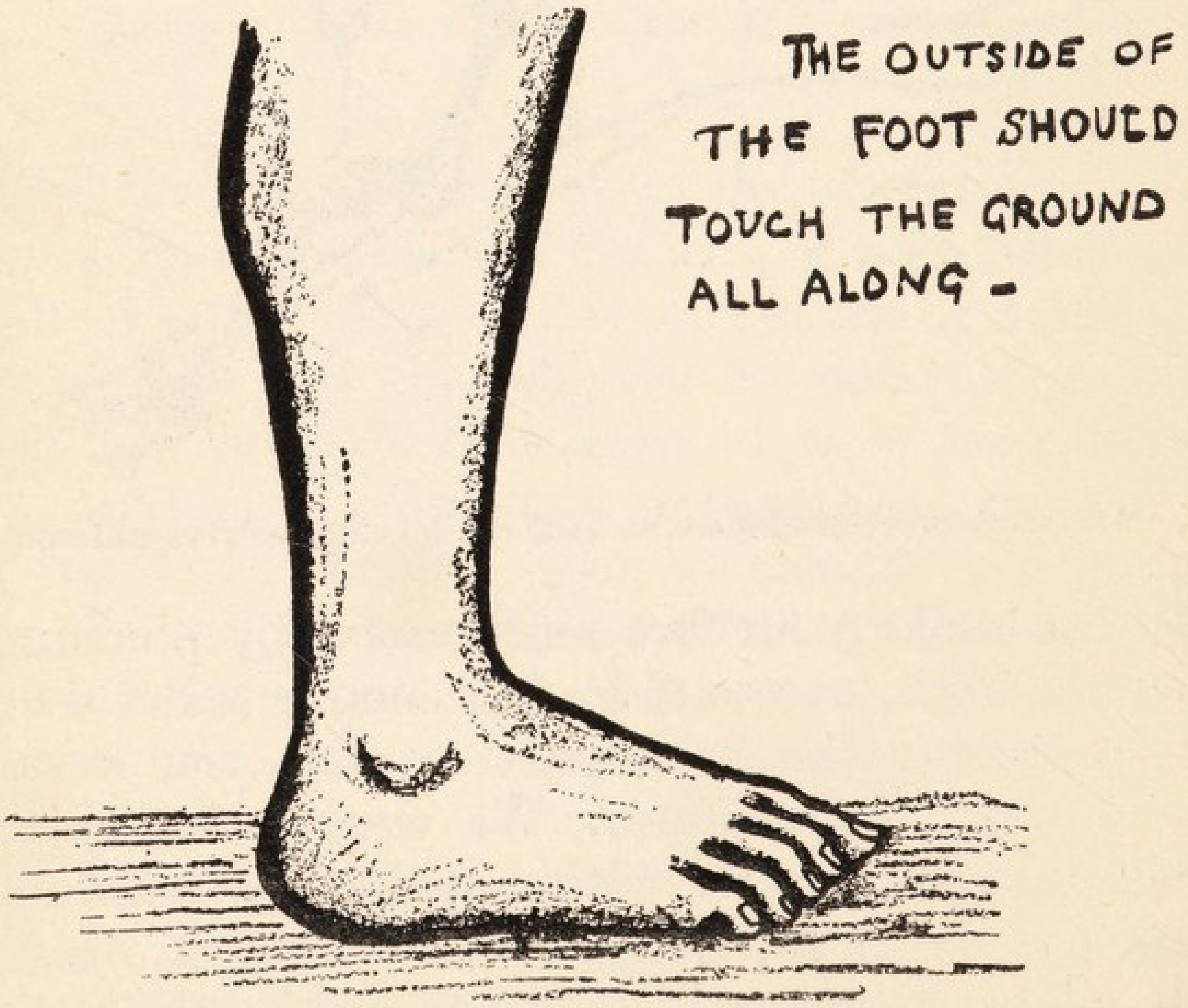
"This great tractor combination at the back is called the 'calf.' It pulls up the whole weight of the body on the balls of the feet, or toes, when we walk or jump. Some call it the Tendon of Achilles, because he was able only to be wounded in his heel. In animals that have to save their lives by running, it is not only stronger, but the lever of the heel is made longer, so that he can jump farther each time. (Picture 57.) All four-footed animals run on their toes, as you see. The tendons of the tail of a whale are as big as cart-ropes. (Picture 56.)

"As you grow older you will hear a great deal of talk about high heels and pointed toes and flat feet. Remember, our bodies are the result of ages of a very wise central adapting them to the uses for which we need them. So don't think that



57. Animals whose lives depend on their quick speed have longer levers.

you can make your feet more useful by pinching them in front, as would-be fashionable ladies did; or by raising the back part so that you never stand on a flat surface. We were intended to walk on a flat surface with a springy arched foot with a wide front, and a nearly straight inside line. The motors will keep everything in their places, and will look best, too, if you make your boots just to protect them as they are and not try to change their shape. Only the bones of the inside of the foot are arched; the outside of the foot should touch the ground all along. (Picture 58.) What makes a machine really beautiful is that it shall work perfectly and be as simple as possible. That's true whether it be a foot or a dress. Silly fashions and bangles that really hinder achievement are never truly beautiful—that's why we gave up wearing diamond rings in our noses, and now only wear them round our necks or fingers."



58.

CHAPTER IX

THE WIRES OF COMMUNICATION

All Communications are Addressed to Nerve-cells

"We might as well try to understand how a modern city works without knowing about electricity, as understand our bodies without knowing about the nerves. So we will talk about them to-day.

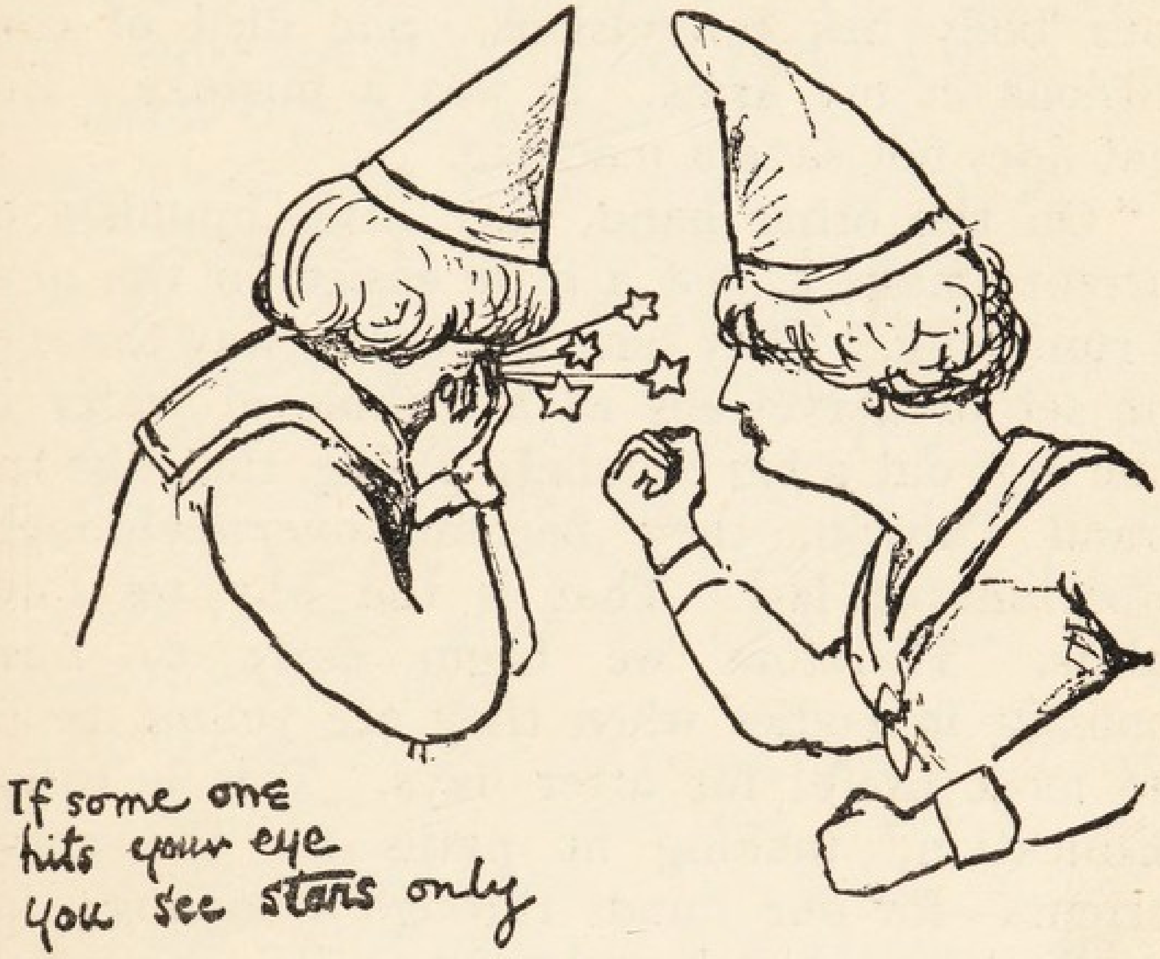
"Some people complain of being 'a bundle of nerves.' Well, every single cell of the body that is alive has to be connected with a nerve, so really we all are that. Of all the wonders of the body perhaps the nerve-cells are the most marvellous. And yet they are very simple. We have already talked a little about nerve-cells, and the masses stored away in the skull as a medium through which we ourselves communicate with our bodies and the world. Some think that nerve-cells are nothing but a lot of electric batteries, though their current travels only about a hundred yards a second, while ordinary electricity travels a hundred and eighty-six thousand miles. Some of these batteries are connected by long wire cells to the sub-stations in various parts of the body, especially to small ones in the chest and belly. These are very sensitive and automatic, and are called sympathetic ganglia, which only means ‘ nests of cells ’ forming centres.

“ Other masses of cells in the brain are called ‘ special centres,’ because they are all for one job—like the breathing-centre, or the centre for looking after the pump and pipes, called the vasomotor centre.

“ The wires, of course, conduct the currents; the central part of the nerve wire is called the axis cylinder. It is made of the best conductor of currents known to man.

“ The nerve currents, of course, go both ways—first to the brain. These are called centripetal, that is, seeking the centre. Secondly, they go away from the brain. These are called centrifugal, flying from the centre. The first are carrying sensations, *i.e.*, ‘ feelings,’ like smell, or sight, or pain, or sound, or taste, and therefore are called, also, sensory nerves. The others carry currents that start something going, like a muscle or a gland, and are called therefore motor nerves, because they say ‘ get a move on.’ There really is very little difference between the two kinds, probably none, except that the ‘ broadcaster ’ is at the outer end of a sensory nerve, and the brain is the receiver at the inner end; whereas the brain is the broadcaster for the motor nerve, and the muscles the receivers at the outer ends.

"You can graft a motor wire or axis to a strange sub-station, but it will do only what the sub-station tells it, so we know that it is nothing but a wire. Thus, if some one hits your eye you



59.

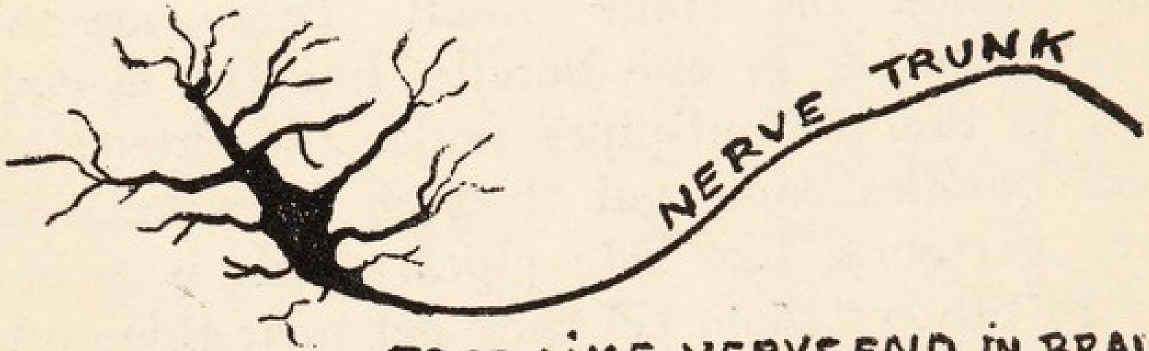
see stars, for whatever you do to the eye nerve, the eye station sees light. It never hears a sound or smells a drain. If you do the same thing to the ear nerve it hears sound and does not see light. Sub-stations prevent any back currents, or messages going back the wrong way. There is also a fine blocking system to keep the currents or impulses from spreading to all the cells in the brain. This is necessary because they are all so close together. You can break the block or insulating system by a dose of strychnine. Then the current runs everywhere. Every centre gets going, as they did in that little girl who ate the tablets which we had sent to her father, and your body has convulsions. She died of convulsions in my arms. It was a mistake. But that does not save a machine.

"On the other hand, tiny little impulses or currents make it just a little easier for the next to run along. They tend to make a way through one set of nerve-cells as a dribble of water in time digs out a big channel; so big, that like the Grand Canyon, they become overwhelmingly important at last. That is the way we form habits. Therefore we begin early to form channels in bodies when they are young, to be the most useful for after days. This is called 'Education,' making fit paths for the nerve currents—for our minds through schooling; for our bodies through athletics; for our spirit through worship, so that it is easier to tell the truth than a lie, to be clean and fair than filthy and unjust. Habits are really sets of old channels. But though every cell has to be educated, cells are not created all alike. Handel and Mozart started with a better musical department than you or I; Raphael and Turner with a better colouring department; Caruso and Patti with a better voice department. But often it is we that make a complete block and even kill the machinery, though perhaps we only let it rust out. We can improve our own machinery by working at it.

"People used to think that the wires were hollow and carried nerve juices. They run everywhere from the brain. Great bulks of main lines run down together, as you saw, in bundles in a canal inside the spine pillar. These are all bound together in one bundle, like the electric wires in the conduit-pipes under the sidewalks. Small bundles come out through holes between every vertebra, like side pipes. This is a fine way to protect them till they get near their job. Then they bid one another good-bye, and each goes off to look after his own special work, whatever it may be.

"All the nerve-cells are small, but of different sizes. They have an outside coat, which has only recently been discovered. This is full of protoplasm, and in the centre of it is another kind of protoplasm, separated from it by still another coat, said to be only one ten-millionth of a millimetre in thickness. It is made of tiny fat globules and is a marvellous insulator, more so than the glass of a Leyden jar. This inside is called a nucleus—which means the centre of importance—just as the first ten cents which you put in your bank is a nucleus, or centre, around which the rest will gather. These nuclei watch over the nourishment of the cell and of the whole axis cylinders, and they alone can make cells grow.

"The end nerve-cells are the most raggedy things imaginable. They are so like a tree with endless little branches that they are called 'dendrites,' which is only the Greek for tree. Here is one. (Picture 60. 'The dendrites of the cell branches; the trunk or axis cylinder.')

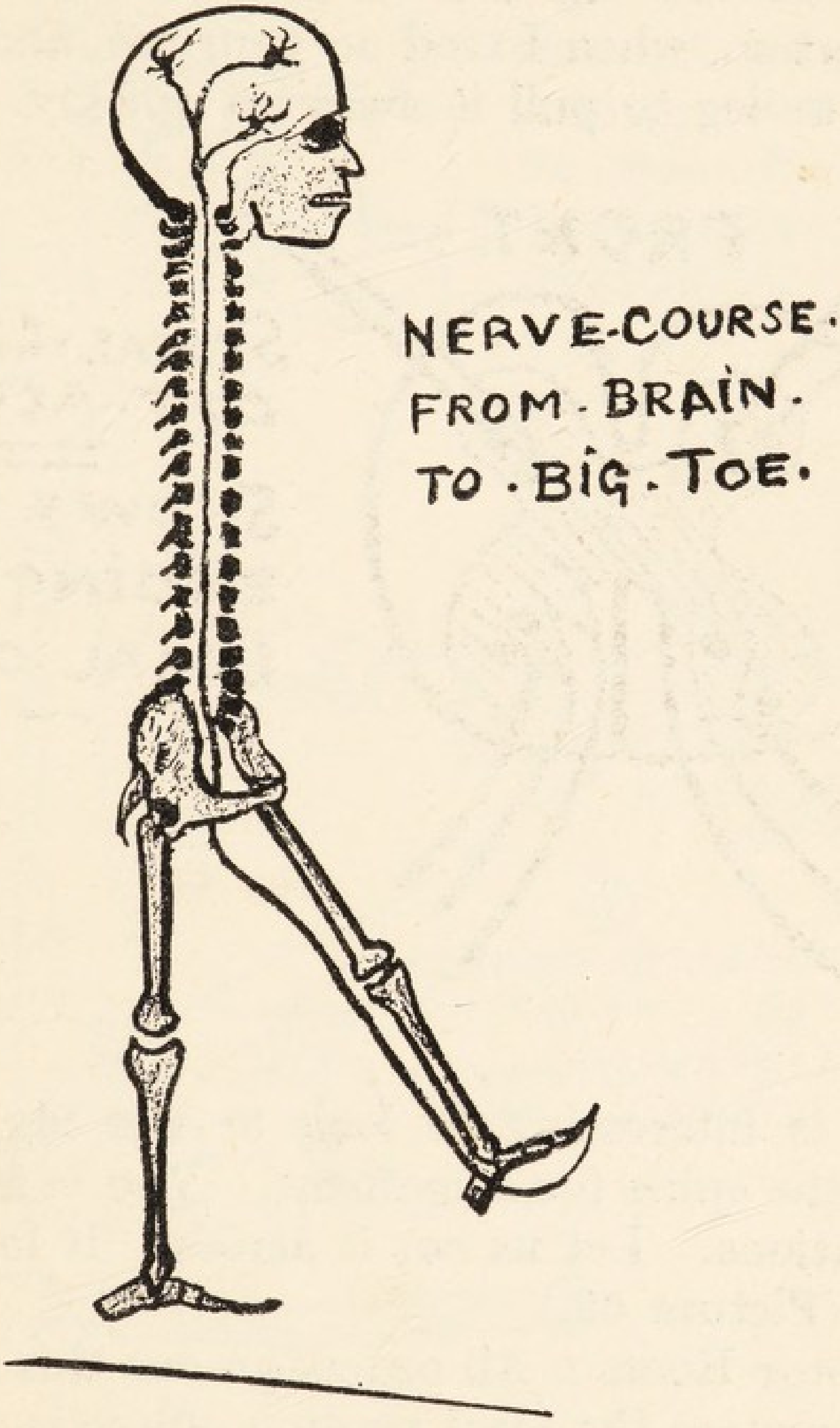


60.

"The nerve-fibres, or neurons, may be yards and yards long. The dendrites are just like the threads of a web. They grow from nerve-cells in between millions of others. They do not join them, but just steal away electric currents for their own cells. The body is as full of dendrites as the air is full of the sounds which only the radio machines can separate.

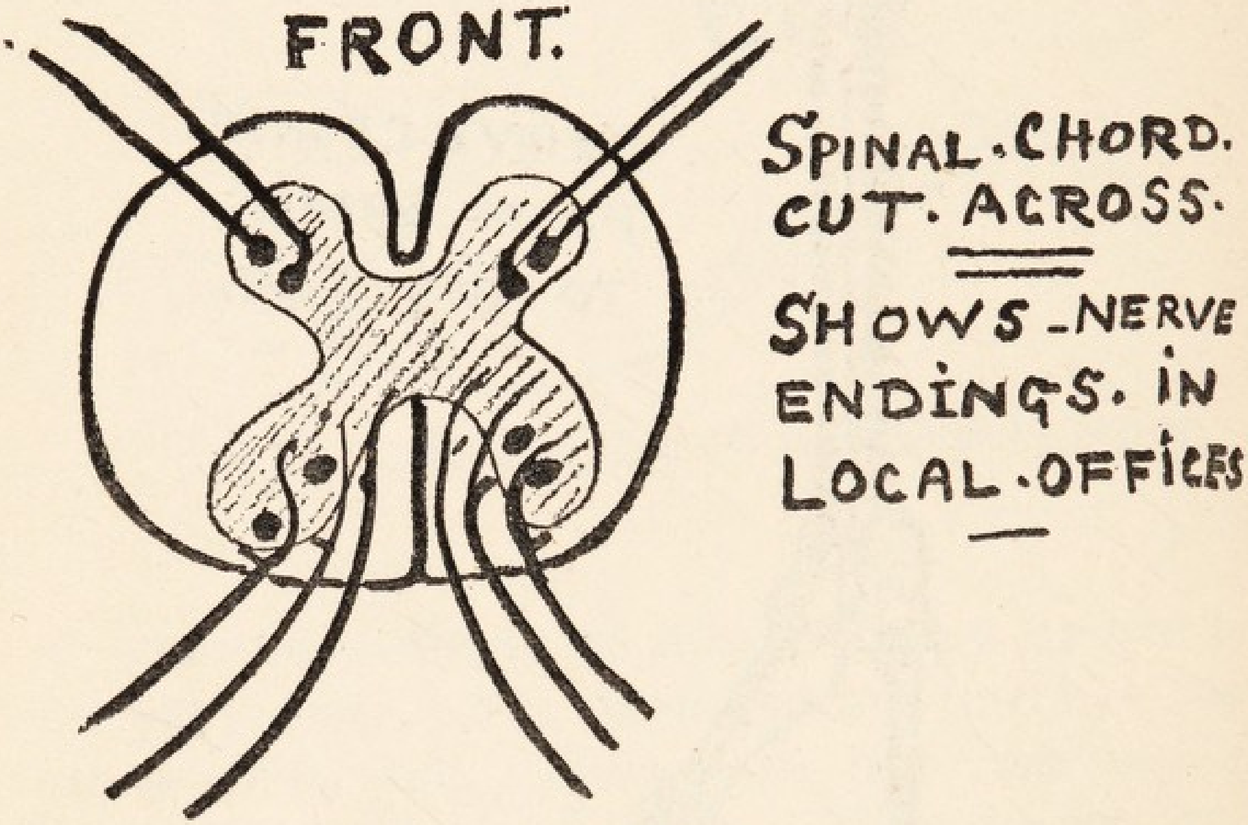
"As the main trunk gets farther off from the main station, of course it gets smaller, just like the top branches of a tree. It ends in the tiniest branches—it may be in the big toe or the little finger, or heart or liver or eye, or anywhere.

"Here is a nerve-cell and its axis cylinder, or trunk, which is carefully wrapped round as soon as it leaves the skull, in a sheath that protects it



61.

and insulates it like the rubber around the copper wire. Remember it is tied up with millions more in bigger bundles when it starts. (Picture 61.) Here you can see it branching out to end in the big toe. Perhaps it is the one that hurt so, when I trod on your toe, and which told your leg to pull it away so quickly.



62.

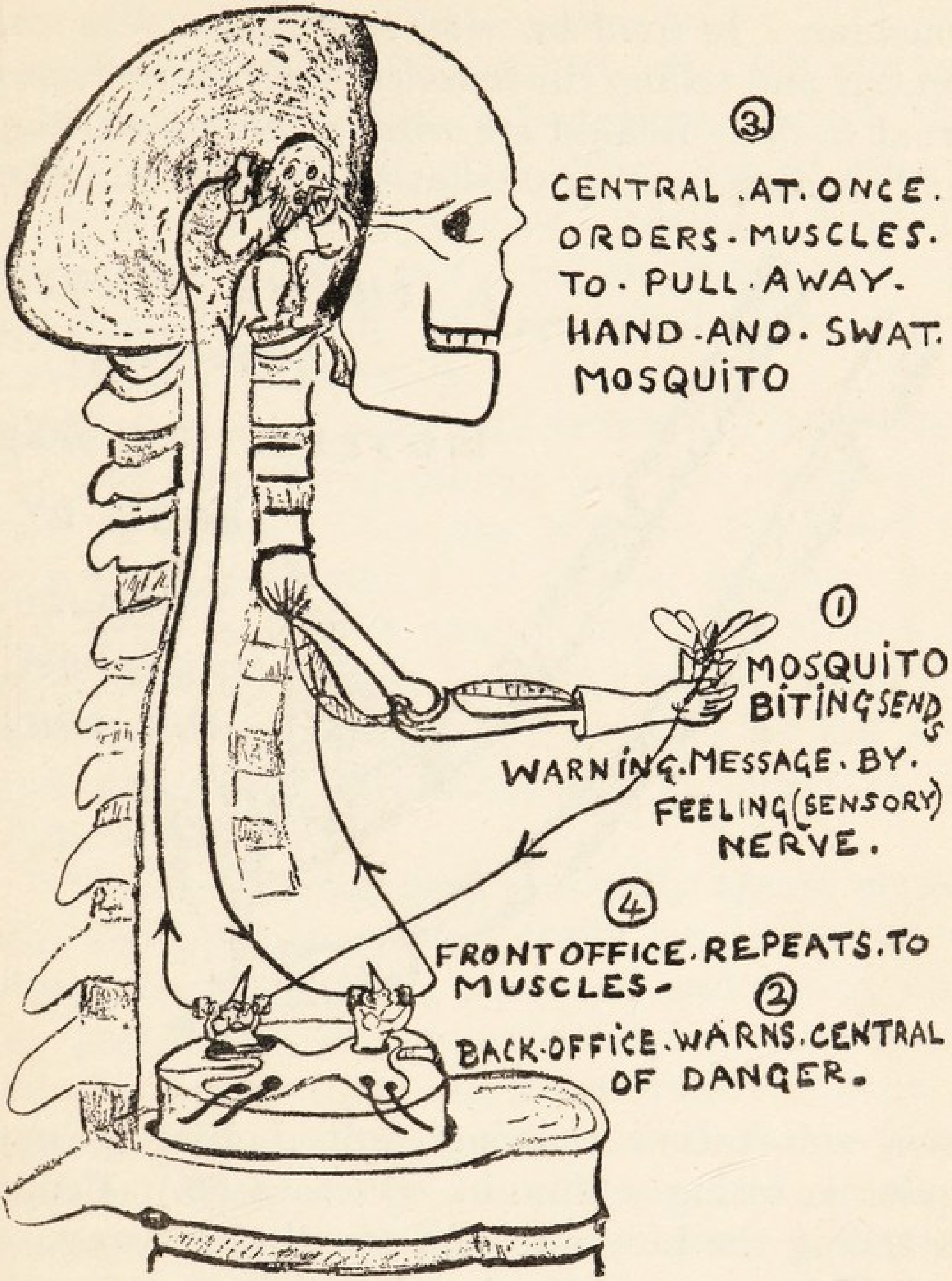
"It is interesting to look at the big bundle inside the spine for a moment. You can see the sub-stations. Let us cut it across. It looks like this. (Picture 62.)

"Motor Roots : All orders go out this way.

"These are the local sending offices in front.

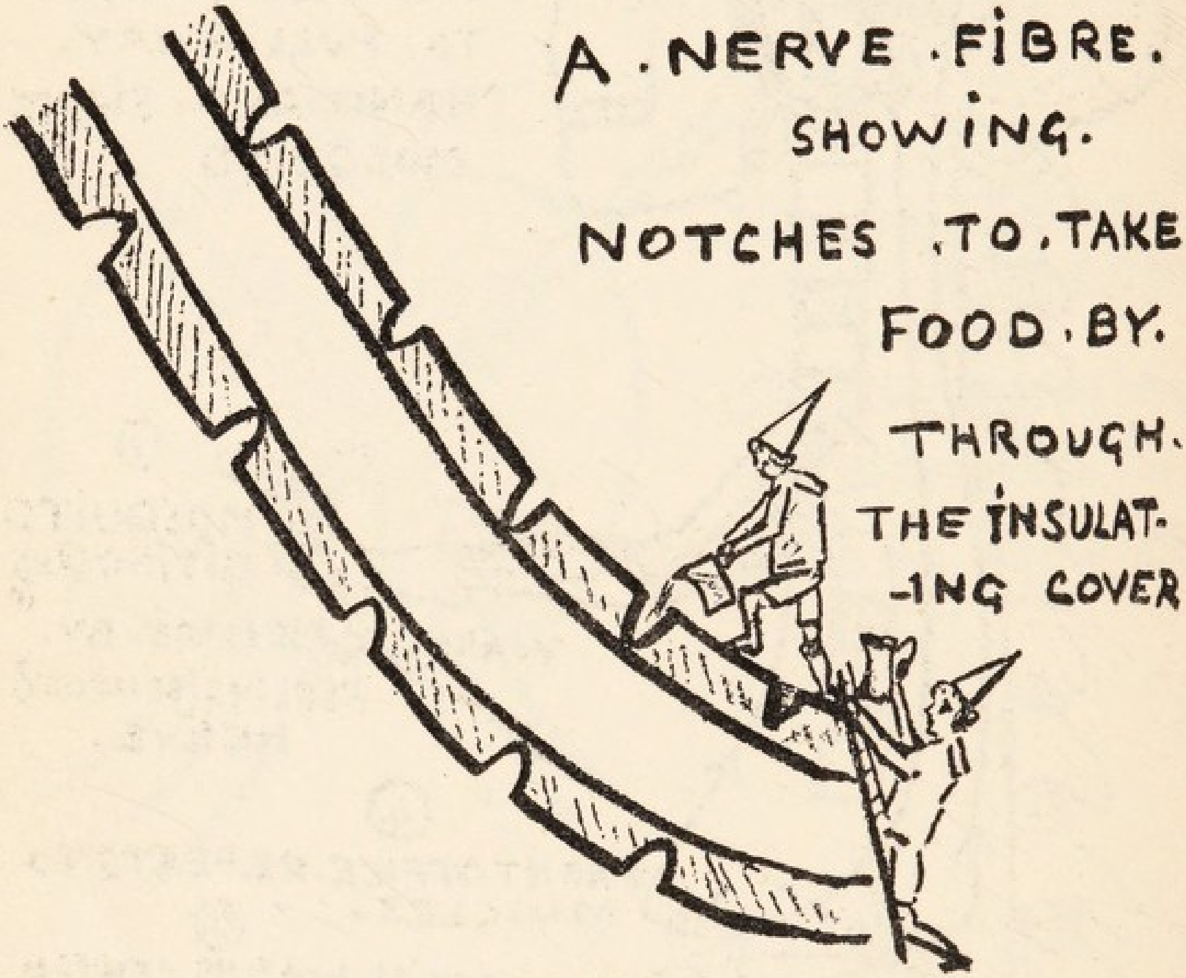
"Behind are the local receiving offices called Sensory Roots. All messages come in this way.

"The black cells are not really little men, of



63.

course, but they do better and more work than lots of men I have known. Each half in the trunk is the same as in the rest of the body machine. In front lie wires receiving orders from central and telling the muscles, such as the biceps, what to do. Behind are wires receiving warnings and sending to central what the trouble is. Here



64.

is a sub-station warning central that a mosquito is biting a thumb. (Picture 63.) Central is telling the biceps to pull the thumb away.

"There are white trunks and grey trunks. The white ones are really only grey ones with a white coat on. The grey ones have not got any insulating coat, so they are more sensitive. The nose nerves have no coats, so when anything gets into our noses that ought not to be there, we instantly sneeze and blow it out. The nerves from the small local sub-stations, called the sympathetic, are like that. They are all grey—ready to act at a moment's notice. A prize-fighter knows this and tries to knock out his opponent by a hit on the sub-station of the nerves near the stomach.

"Here is a 'white coat' trunk. (Picture 64.) The cup-shaped depressions you see occur regularly all along. They are to allow the blood to give the trunk, which, of course, is alive, food and drink as it goes along. The striped coat is the insulating rubber, and the black outside is only the strong safety coat to carry all the soft stuff safely to its destination. It ought to be white really.

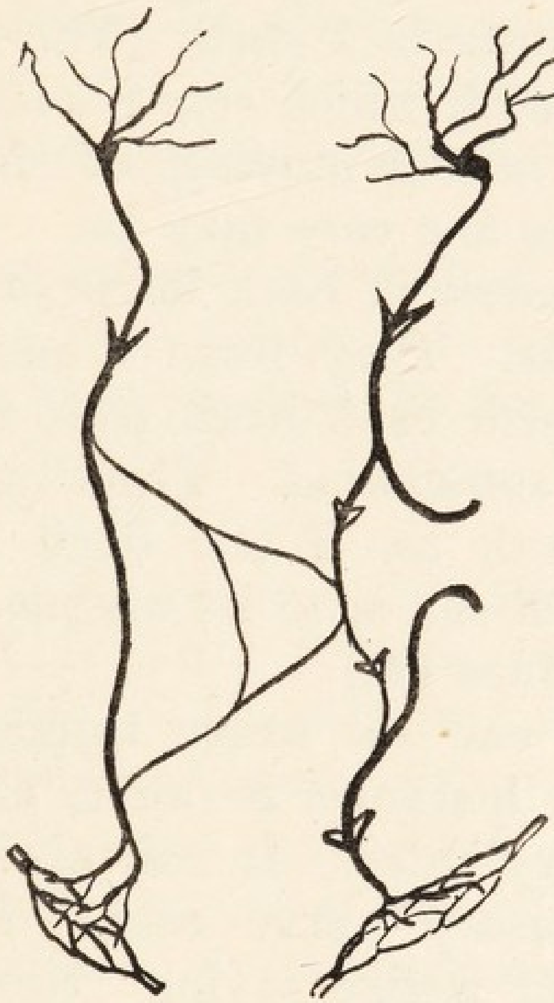
"We are talking very learnedly about nerve-cells and protoplasm, but really we do not know why a nerve-cell feels, and sees, and tastes, and the protoplasm of a muscle-cell only contracts. We do know that anything which makes a chemical change in anything starts it working, and that that change of substance taking place starts a current instead of starting a simple shortening of the cell, as it does in a muscle-cell."

"What is a chemical change, father?"

"Nowadays it is understood to be simply a change in the substance of which anything is made. When you burn a candle the wax becomes smoke or carbon. The candle has had a chemical change. When you put hydrogen gas and oxygen

65. A chemical change.

together in a glass, and send a spark through, they unite to form a changed substance, or a new substance called water. The same stuffs may be there, but they are in a changed combination, and appear to us to be new substances. Thus you leave your new knife out in the rain; instead of being bright steel in the morning it is red rust. The oxygen of the air has made a new substance, burning the steel and joining with it to form rust, or oxide of iron. These are all chemical changes.



66. Détour between brain and muscle, main wire broken.

" The ends of the sensory nerves in the brain spread out exactly as do the motor ones in the toe, for instance, and they put their ends so close to motor dendrites, or branches in the brain, that though they do not exactly join, the current leaps over from one to the other. It is very clever how it does it. The little space is called a synapse—that is, ' arranged together,' and the same thing happens here as at the other end of the wire, where it ends in a muscle. There is a kind of explosive substance in these synapses which acts exactly like the detonator does in dynamite in a shell. The nerve current is the slow-match which sets it off. It explodes and sets the muscle moving, or the shell flying into pieces—as the case may be.

" Axis cylinders of both kinds of nerves break up into fibrils. They form a network (Latin, *plexus*) in which each fibril ends in a plate, or in a cell of some kind. These plexuses are a great safeguard, as, if one fibril is blocked or breaks, the cell can send its messages round by a détour. (Picture 66.)

" The cell can do other things through its nucleus. For instance, it orders all refreshment for the axis cylinder. It can also refuse to do what the sensory nerve asks. This is called inhibition, and is like saying ' Ring off ' to the man at the other end of the telephone. The current we call ' fear ' may do this. Thus in the olden days when a woman was accused of being a witch she was given a dry biscuit to eat quickly. When you see a biscuit your mouth waters to wash it down. Your eye and your nose are telling your mouth to get ready. But the punishment of a witch was so cruel and horrible that some people were so terrified that the nerve-cells in the brain became so paralyzed with the fear current that they gave no orders to the glands to pour out saliva. The poor prisoner's mouth was therefore quite dry. She could not swallow the dry biscuit, the stomach cells will not allow dry flour to come down. So the poor witch was burned or drowned or tortured simply because fear 'inhibited' her salivary glands.

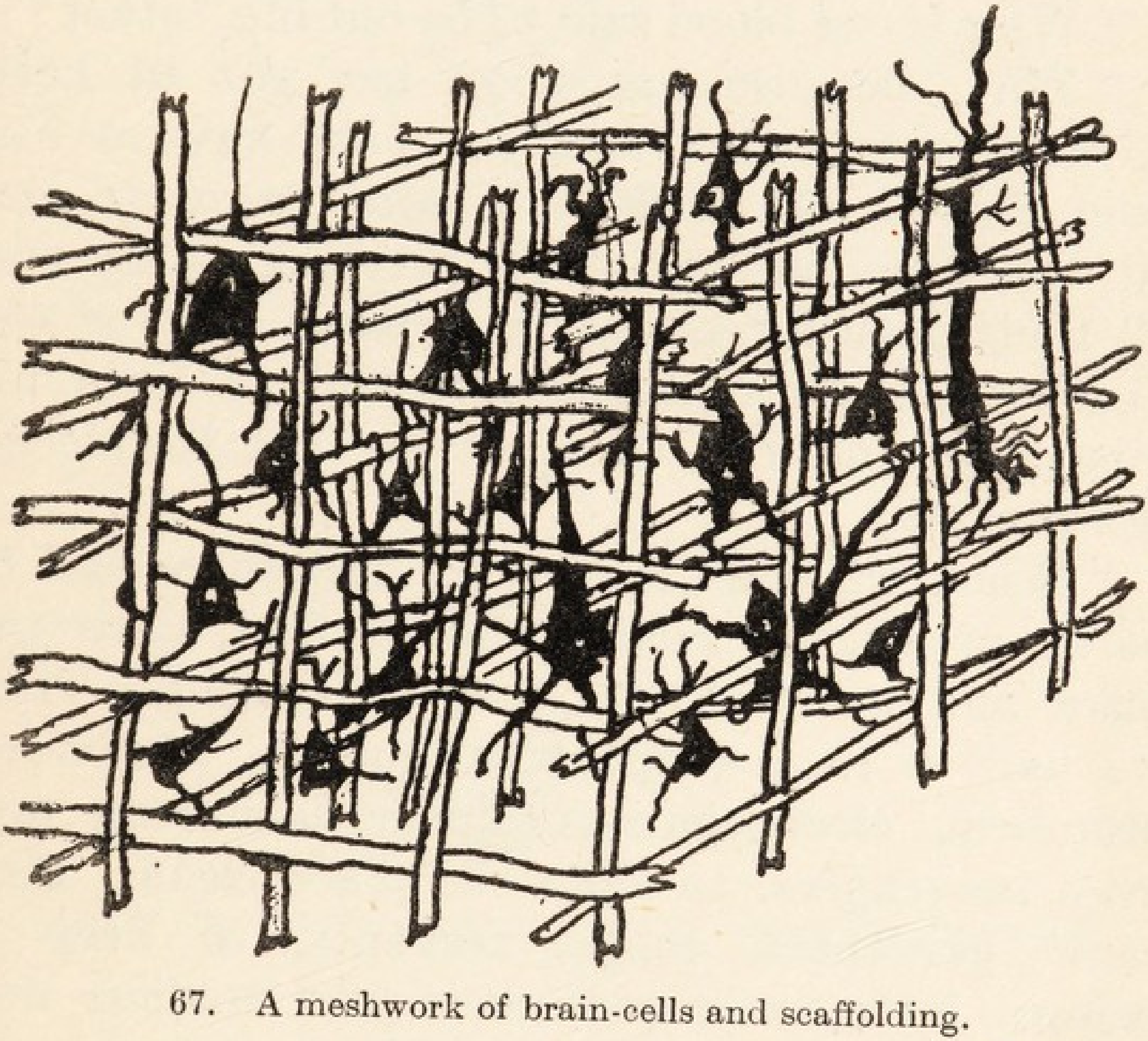
"On the other hand, the Indian, when he was tortured, could force his hand to stay in the fire, as Archbishop Cranmer did the hand with which he wrote his denial of his faith. We can learn to control the fear current.

"With our knowledge it still seems a strange thing that not only our will can tell our motors to act, like telling our mouth to make a speech, but other people's wills can also do it. We call that mesmerism, and used to think it supernatural. But it is easily explained, for impulses or orders are able to fly through space like those of wireless telephones or radio, and so make a far-off machine talk and sing and laugh and play. So why cannot our machines, which are so much more delicate, do the same thing? Never make the mistake of thinking that a thing cannot happen because you do not understand how. The men who think they 'know it all' are hasty and dangerous people. Always be modest about what you think you know and you won't go far wrong.

"When your mouth waters at the sight of ice-cream, that is called a reflex act. Your will is not consulted. A sub-station does it for you. You might forget and get indigestion and waste the food, if it were left to your management. Thus, when a baby has to try to walk, it has to think and use its will to tell its feet where to go. But slowly a local sub-station in the spinal column is formed, and then it walks better. Walking becomes a purely reflex act. It needs about three hundred muscles—with each step we use fifty-four muscles, all working together. We could never issue fifty-four orders at once.

"The heart, and one or two other sub-stations, however, do even better than that. They learn to manage their own job entirely, and they go on beating regularly like a pendulum, without any one to pinch them or shout at them. That is really 'automatic.'

"There is another thing to remember before we leave 'The Nerves.' It is this. Nature makes every possible provision for taking care of the delicate cells; the finest of fibres, elastic and strong, are woven round and between them. Along these run tiny pipes, with food and oxygen. Special material also is stored there for making nuclei and refreshing tired-out cells. This mesh-work is called 'neuroglia'—it is the scaffolding or framework of the brain or ganglia. But remember this; just as muscle-cells, nerve-cells may be so badly overworked that they can never recover. Go on long enough abusing and using a tired nerve-cell and it just dies. No amount of rest will bring it back again. That is why we say: 'All work and no play makes Jack a dull boy.' So 'scoot' and play 'instanter.'"



67. A meshwork of brain-cells and scaffolding.

CHAPTER X

THE BLOOD

"Why is our blood said to be our life, father?"

"Why, because our body has got to keep alive in every part, and we must have a live fluid, full of live workers, flowing to every part all the time, all our lives, carrying them and all their gear for continual repairs, just as old Feather Top, the Scarecrow, had to keep his pipe alight all the time, or he fell to pieces. (Picture 68.)

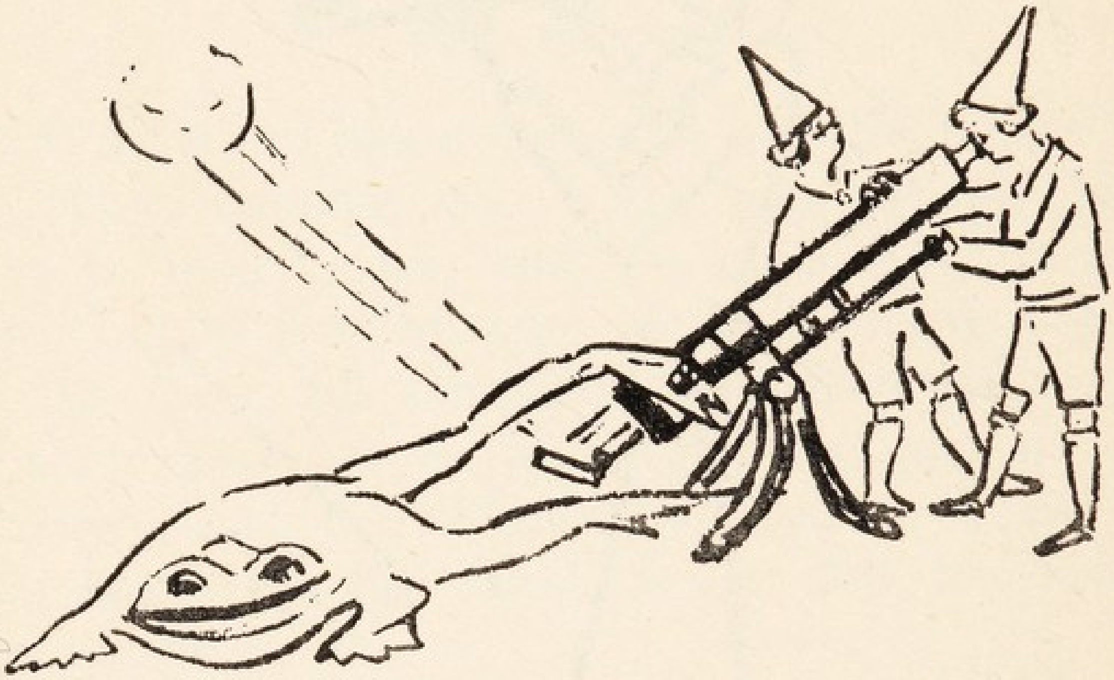
"When we built our home, first there had to be an architect. Mother did all that, drew the plans and watched over the whole thing. Then we had to have carpenters, masons, plasterers, plumbers, electricians, ordinary labourers, and even scavengers, to keep the place clean; then came gardeners, cooks, servants, to keep it going; later came policemen and soldiers and sailors and lawyers to keep it safe; and merchants to keep it fed and clothed. All these jobs have to be done for our body house by the blood and its myriad little workers. They are all very tiny or they could not possibly get into any ordinary-sized body—we should all have to be

68. Old Feather Top kept going just as long as he kept smoke in his pipe.

immense giants, clumsy and no good in a world like ours."

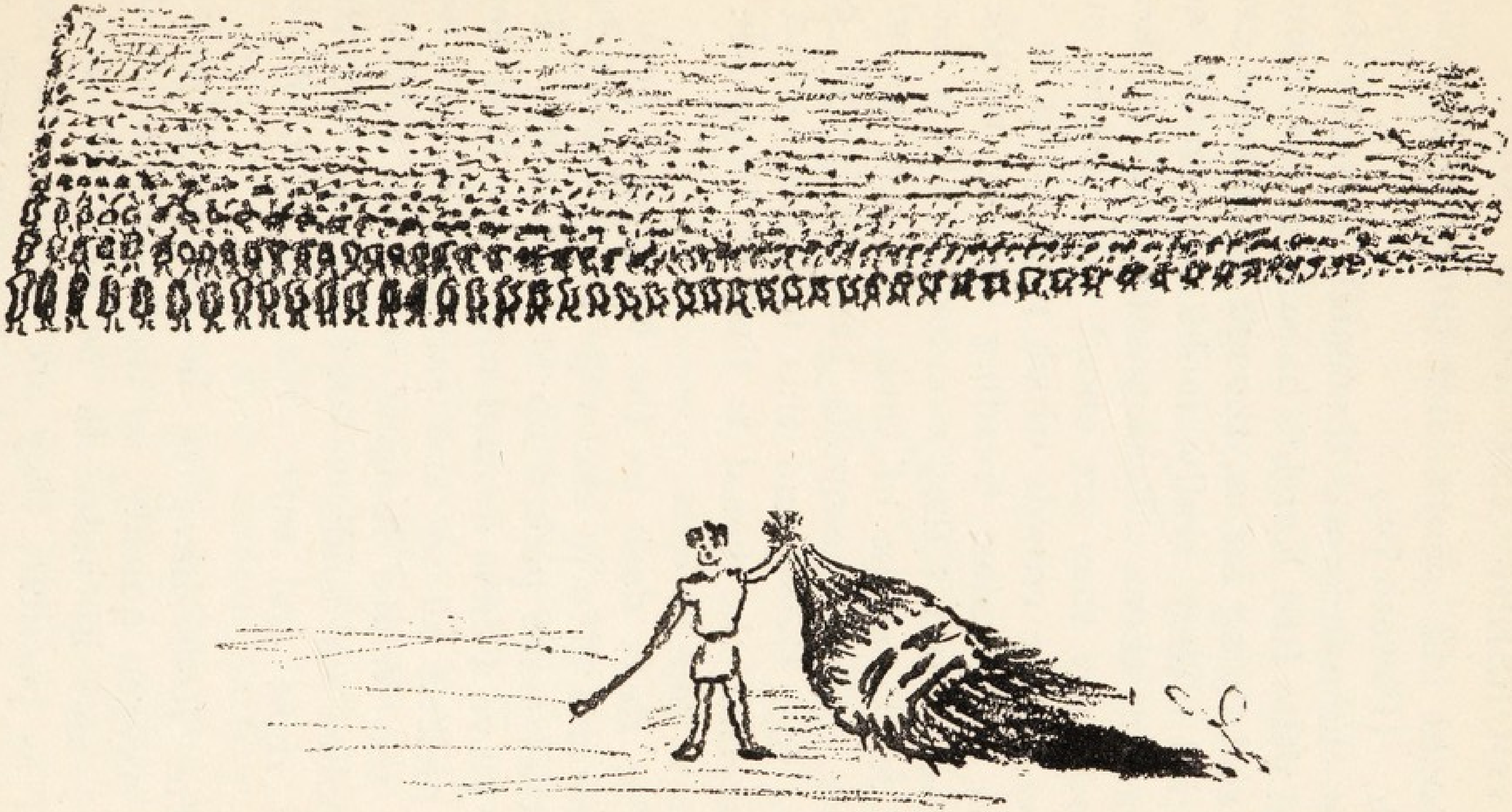
"Can we see these workers?"

"Certainly we can. Here is a frog. (Picture 69.) I am not going to hurt it, but just to put the web of his toe under the microscope. Now what do you see? A lot of little red dumb-bells tumbling over and over, and passing quickly along inside some pipes. Anything else? Look carefully. A roundish white fellow. But he is



69. You can see the corpuscles running through the vessels.

only crawling slowly along. Right you are. Those are far the most important servants we have. They are so small, however, that until the microscope was invented, no one could see them, and so did not believe in them. About ten thousand are in every cubic millimetre of blood. But strength does not always depend on size. A cow is bigger than a wolf, but the wolf eats her. A man is bigger than a consumption germ, but the germ kills him, though it is so small that ten thousand of them can sit com-fortably on the point of mother's needle. Little



70. Size doesn't always mean strength. Millions of little things do big things.

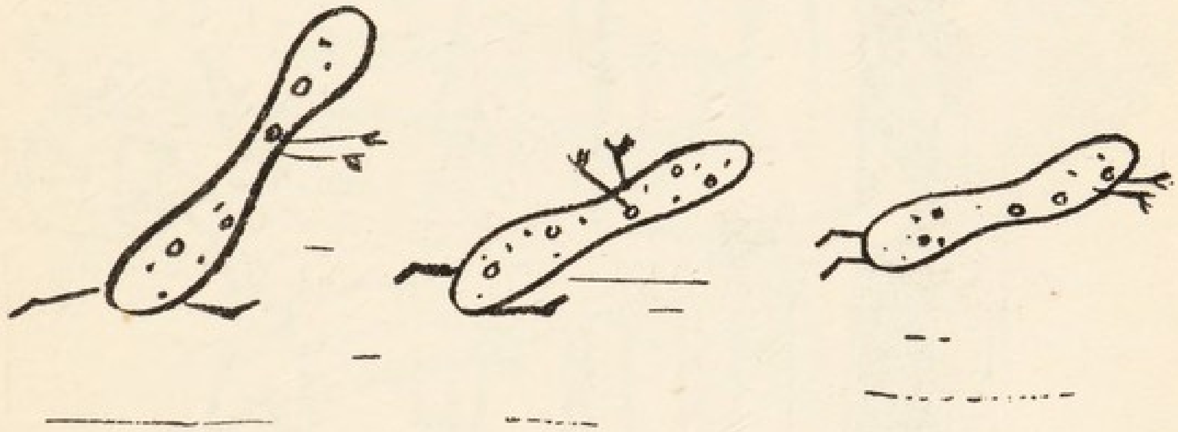
Jack could kill giants, and little David killed Goliath. (Picture 70.)

"For thousands and thousands of years these faithful little Red Knights have been our friends, living and dying for us, though we did not even know it! They really build our bodies and take care of them. Take another look at them. See how busy they are about their affairs, just as busy as the crowds which rush about in the trolleys and trains, treading on one another's very toes. Aren't they wonderful? It is useful to know the shape of them, because no other animals except mammals have their red corpuscles like them, and this fact has helped to tell whether the blood is that of mammals or not, in a murder case.

"The Reds dash to the lungs and grab up oxygen and give in exchange ashes and garbage that they have picked up at their work. They never leave a mess around when they have done; they pick it all up and carry it off, and then come the White Knights—the real scavengers and police and soldiers—and see that everything is all right and safe. We will talk of them later.

"The Reds have to be ready to give up their oxygen quickly, so they carry it on their skins; and in order to be able to carry as much as possible, they are shaped like this—and they arrange so cleverly that their skins altogether are fifteen hundred times as big as the skin of the whole body. Does that puzzle you?

"Here is a Red. You see he is carrying bubbles of oxygen. (Picture 71.) He fixes it with some jelly-like stuff called hæmoglobin, and that is what makes him so red, and why your face gets red when you have been out in the

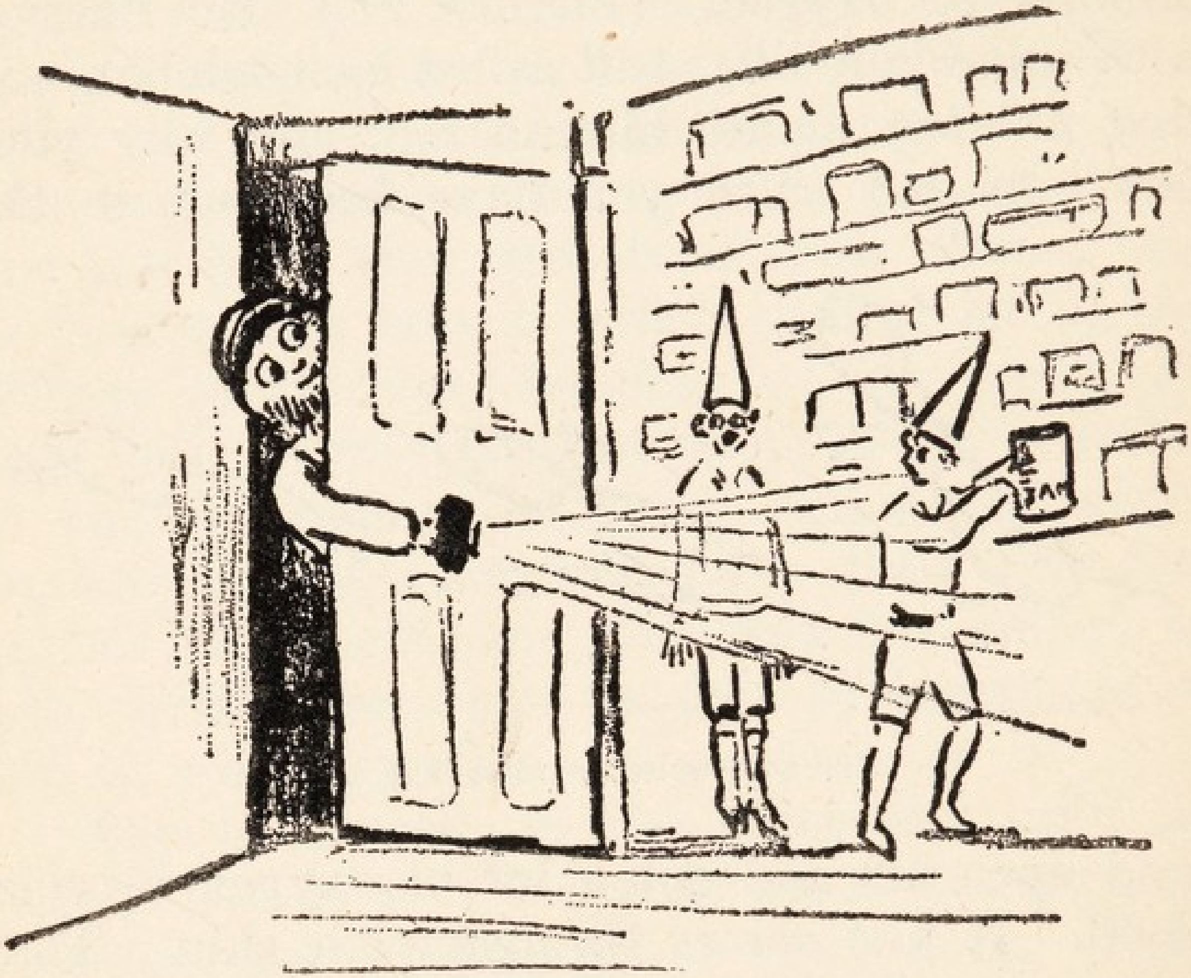


71. Red corpuscles are always in a hurry.

good open air and got a lot of oxygen in your blood. It just shows through your skin. That is the way the Reds keep up steam all over our body, by burning up the food and tissue. That is how they keep us warm, always at the same temperature, about ninety-eight degrees, and also full of energy.

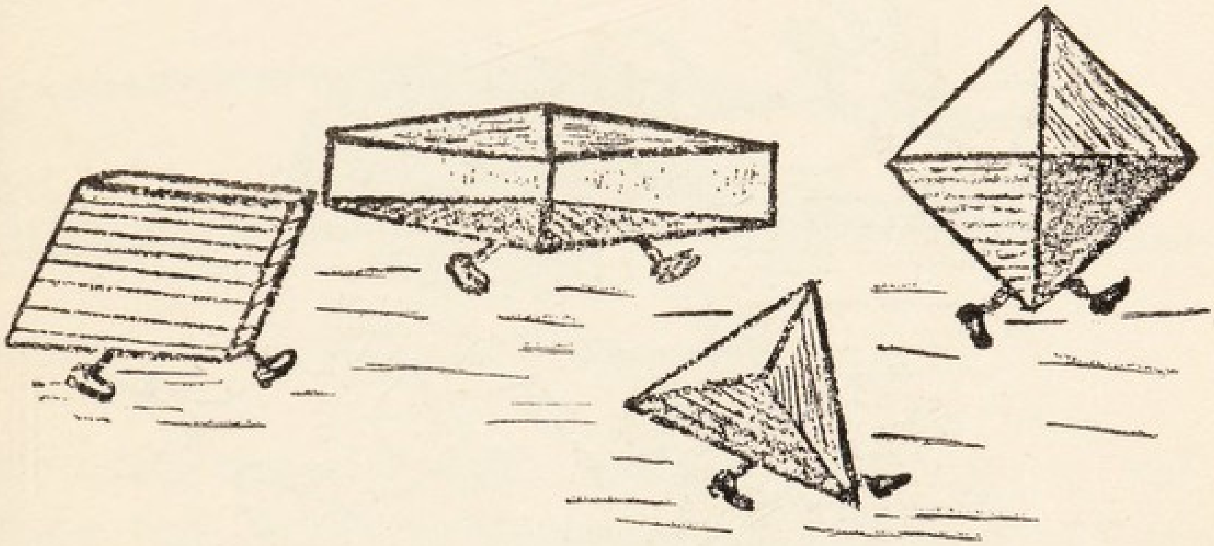
"Now look at a little electric battery. See what a lot of light and heat it gives out. It is full of energy. We call this an electric cell. Well, the red cells, like all live ones, are like little batteries. Men have even tried to measure the amount of electricity in a live cell. Is it not wonderful to have all these 'ever-readies' dashing about giving help every minute, and in every corner of our bodies?" (Picture 72.)

"How many red cells are there?"



72. All "ever-readies" are useful.

"About five million in a cubic millimetre of blood. Twelve thousand side by side make one inch, or thirty-five hundred head to tail make one inch. That makes more in your little body than in all the armies of the whole world put together. You see, if they were not so small they could not squeeze along through the tiny capillaries and get at the cells. They are real red-coat armies, like the old British regiments. Look at them advancing at the double; and double they can, for they can go right round the body in two minutes. They do not live long, but you could hardly expect it, living at such a pace. They get old and die in a fortnight, and even before that they have to go to the sick-room for repairs. Thousands die every day and

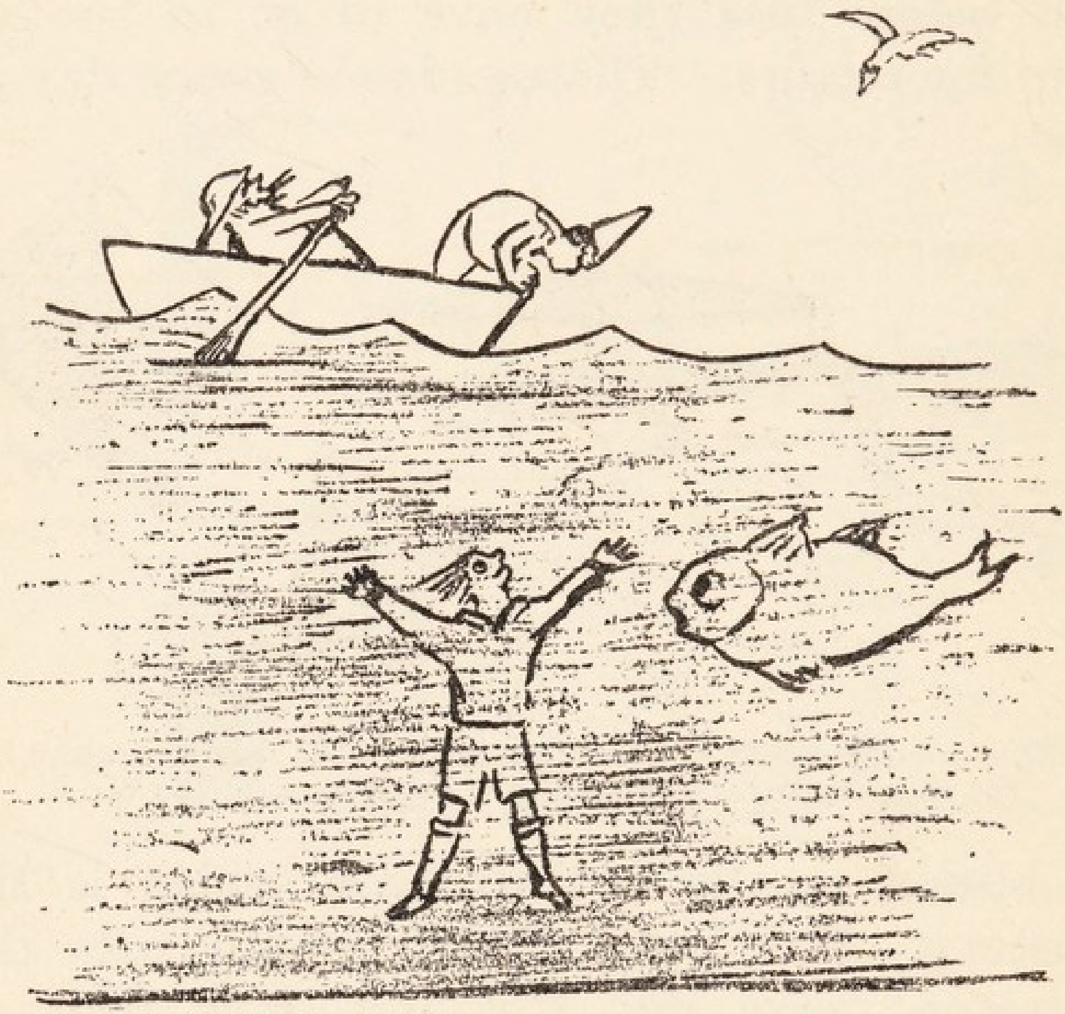


73. This is oxygen held in a red iron grip. It is carried around inside the red corpuscles to the help of every part of the body.

are buried mostly in the liver, which is their cemetery. But just as the ground uses dead bodies to make rich soil and grow fruit and flowers, so the liver cells really eat up the poor old Reds, and use them for making a juice to digest food called bile. Nature never wastes anything.

"Oxygen itself is not red. It combines with the iron to make the corpuscles red. The mixture is called oxyhæmoglobin, and is really oxygen held in an iron grip. (Picture 73.) The more there is, the stronger the cells are, and even when dead, like the dragon's teeth, they spring up again from their grave into more hosts of iron men.

"As they go around, the cells demand their oxygen to burn up the food which they bring

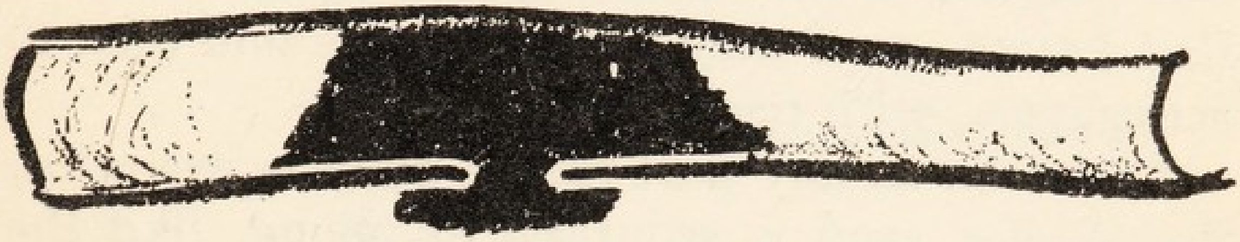


74. Drowning is only having our air cut off.

also. The Reds are generous enough to give every bit of oxygen away, and so they get breathless as well as blue before they get back to the lungs. That is the reason that the veins are blue and the arteries red.

"If you cut off air by staying too long under water, you get blue and will die. Drowning is only suffocation, or preventing the air (Picture 74), with its oxygen, from getting to our blood.

"The Reds do heaps of other useful work. If a leak happens to appear in one of the pipes, of course our body will, in time, bleed to death—that is, lose all its blood. So the Reds and Whites turn plumbers for the time, and help to stop it. We say then that the blood clots, and plugs the leak. (Picture 75.) With the Reds



75. Reds plugging a leak.

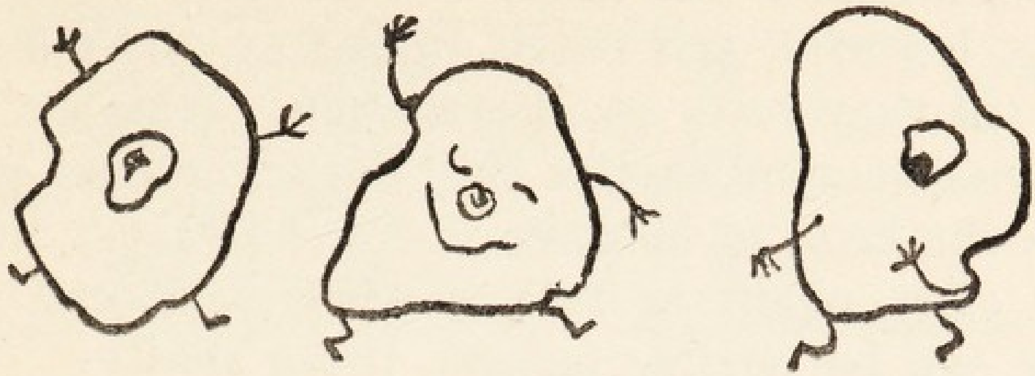
are still smaller cells called platelets. I call them the Bantam Regiment, for they really do most of the leak-stopping, and are such a modest lot of little fellows that nobody knows much about them. But for all that, we could not do without them."

"Tell us more about the White ones, father. What do they do?"

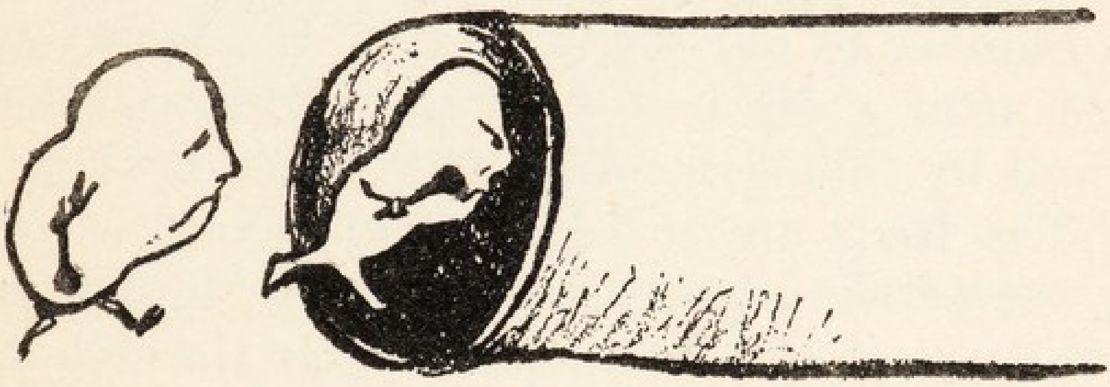
"Oh, there aren't so many Whites as Reds. Only one to every three thousand five hundred. They are larger, and, as you see, do not hurry about like the Reds. But they are the fiercest little fighters you ever knew. They not only kill, but eat their enemies at once, and only when they have safely swallowed them do they march off the battle-field. One thing they can do which is convenient, they can call up any number of reserves if needed. They seem to telegraph to headquarters for more, just whenever they are needed—as if it cost too much to keep a lot of them on their beats in idleness, or in barracks during peace time. There are three main regiments: (No. 1) large with many nuclei; these are the actual Knights; (No. 2) the Poison Gas Brigade, a very secret crowd called Eosin or Red Lovers, as if they loved killing; and (No. 3) Scavengers, with one nucleus.

"As soon as any part of the body is wounded, the Whites send a scout patrol along, like the scout bees when a swarm is going to occur. (Picture 76.) If there is poison in the wound, such as bullets going through dirty soaked clothing carried with them in the war wounds, a real swarm of Whites scurries down. (Picture 77.) In fact, if you are feverish, and the doctor thinks that you are poisoned by germs, but isn't sure, he will take a drop of your blood, look at it through the microscope, and count how many Whites there are in it. If there are too many, say two instead of one in each tiny space, then he knows that the Whites have found germs somewhere, and are hurrying around looking for the trouble.

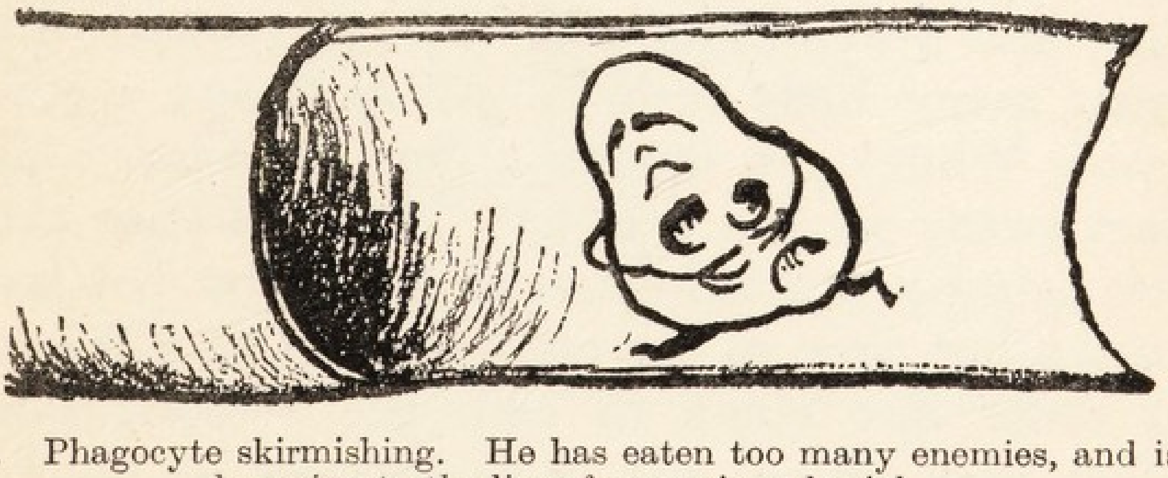
"These Whites don't look to be much, but they really are brave as lions. They do not care how dangerous the enemy germ is. Right there in the dark they dart out on him and kill him or get killed. They can make themselves any



76. Well-fed Phagocyte.



77. Phagocyte off on an S.O.S. call.

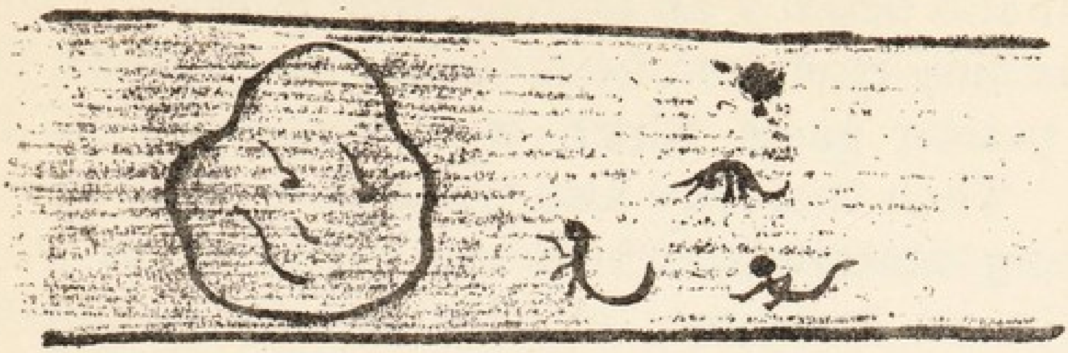


78. Phagocyte skirmishing. He has eaten too many enemies, and is hurrying to the liver for repair or burial.

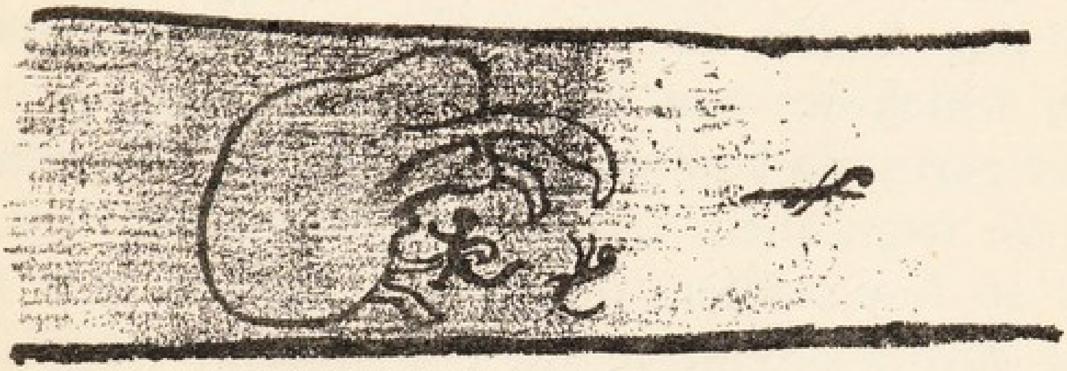
shape, for they can throw out an arm anywhere, a big, big arm, and catch an enemy and cling to him till they have swallowed him. (Picture 79.) Do you remember the tiny serpents that grew from the head of Medusa, and the Hydra's heads that grew again as fast as they were cut off? They can be terrible fellows, those Whites.

"They are called Leucocytes, or white cells, or in war-time Phagocytes—that is, cell-eaters. (Picture 79.) A good cold bath helps to increase the number of our Whites; that is why we feel so fit after a dip in the lake, and why we keep so well by taking a cold bath every morning.

"The Reds are so big that they cannot ever get out of the pipes unless they are broken up, so they send the iron and oxygen through the thin wall. But a White can change his shape like a fairy prince, and squeeze through between the bricks of the walls. So nothing can escape him, and a wonderful policeman he makes. If a great many Reds rush to one spot, and a great many Whites get out in a crowded place, that part swells up and gets hot. It is because they are fighting so hard—indeed, a regular battle is on, 'a hot time in the old town.' Other friends of order also come to help the Whites, since often they cannot eat their enemies as quickly as they come along. One lot of helpers is called Opsonins. They make the enemies' coats soft, so that Brother White can digest them quickly. There are also friends called Receptors, which



(*a*)



(*b*)

(*c*)

79.

(*a*) Picket duty.
(*b*) A Phagocyte skirmishing.
(*c*) He recognizes an enemy and eats him.

catch and destroy all the enemies' poisons. Most of the tiny enemies of our bodies use poisons, like the poison gases which were employed in the war. Then there are also the Anti-bodies, special fighting materials, which are made at so great a rate in war-time, exactly as our munitions had to be, so that lots are left safely stored away in the body. That is what vaccination does for us. It pretends the enemy is upon us, and our bodies at once store up ammunition with which we can fight the next small-pox or other germ, and so our bodies become ' immune,' or safe from their attack. That was the reason why so few soldiers died of typhoid in this last war. Every single one was vaccinated for typhoid. A few dead typhoid germs, or rather their poisons, were put into every one's blood. Every one thus stored up Anti-bodies, and though often a lot of typhoid germs came along into the water in the trenches, the Whites just killed them all with that ammunition, and then had a good supper off them.

" Unfortunately, enemies do win sometimes, and endless brave Whites are killed, as they were in Russia. Their dead bodies are then left on the battlefield, and often any number of dead cells from tissues as well. Many Reds may have leaked out from broken pipes, and died also. The heat and swelling which result from the battle are called inflammation, and the dead mess left behind is called pus, or matter."

"Are the Whites animals?"

"Look at that drop of water. Quite pure, isn't it?"

"Yes."

"Now look at it down the microscope. Do you see anything?"

"Yes, a cell, moving about like a white cell. Yes, very like."

"Well, that is a tiny animal called an Amœba, made of one cell. It can walk about, catch its food and eat it, throw out legs and arms anywhere, become thin and long or short and fat, as it likes. You can call both animals, if you like."

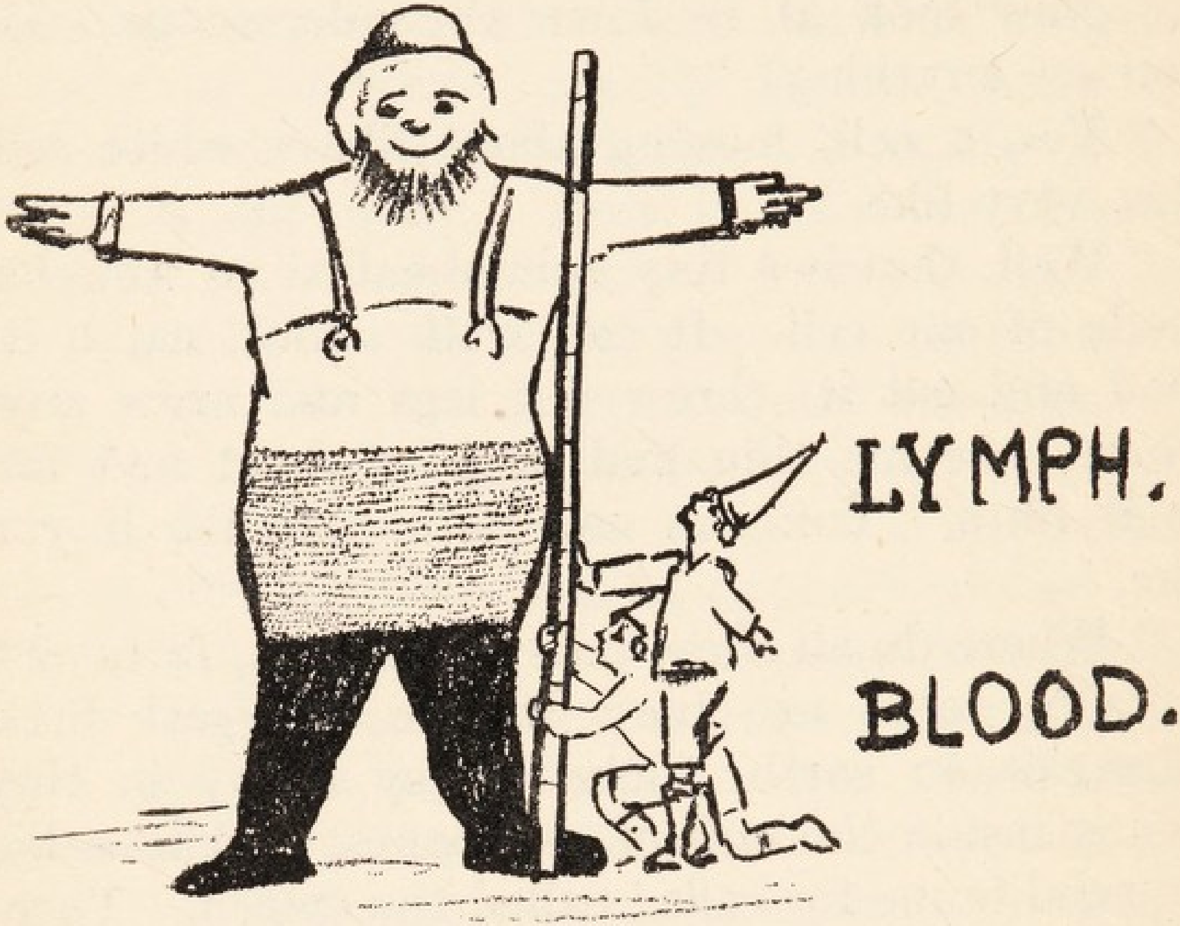
"Where do all these cells come from, father?"

"Oh, some are born in the snuggest little nurseries on earth, tucked away safely in tiny rooms inside the end of our bones, and in a big 'special home for cells,' called the spleen. Then, too, many Whites are born in little local factories all over the body, called lymph glands.

"Perhaps you know that the same amount or weight of material made into a reasonably hollow tube is actually stronger than an equal amount of material in a solid rod. So we can afford to have hollow bones; and birds, which must be as light as possible in order to fly, have very hollow bones indeed. Men even use them for pipe-stems."

"And where do the reserves come from when they are wanted?"

" Several groups of cells help out in various parts of the body, such as cells of local nerve stations called ganglia, or living cells of the

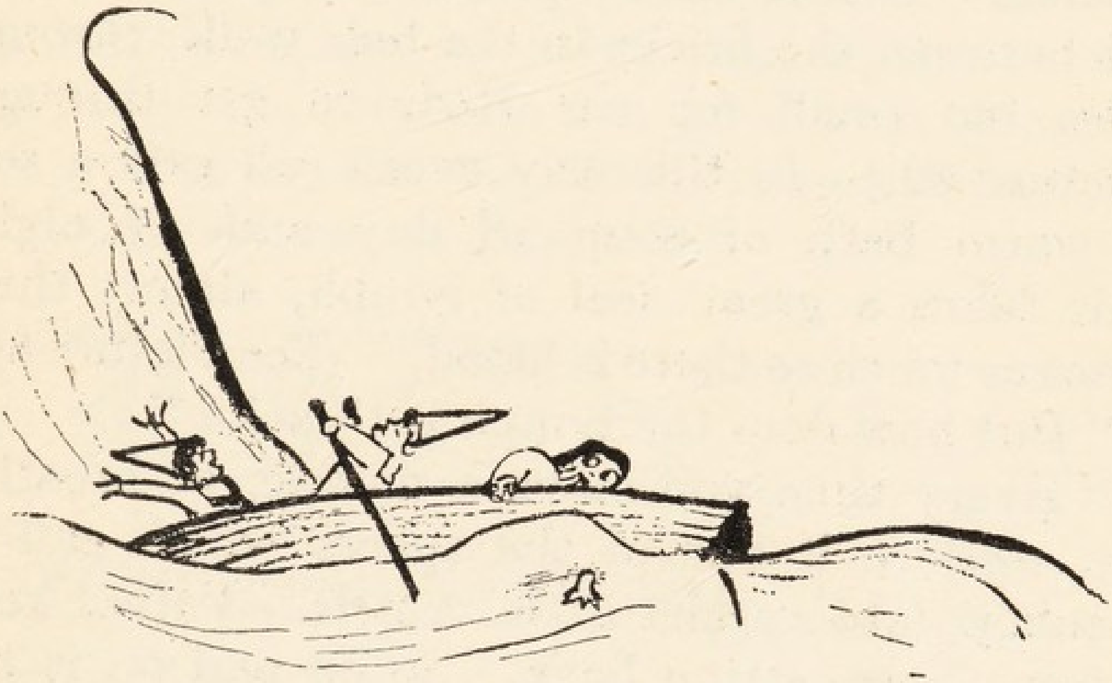


80.

liver and spleen. Besides these mobile forces, there are certain fixed guards that have their home in the liver, in the marrow-bones, and spleen. If anything comes by that would be better out of the way, they politely swallow it."

" How much blood must we have ? "

" We have one pound or pint for every thirteen pounds we weigh. (Picture 80.) I have fifteen pounds; and it is three-quarters salt water. The blood has in it heaps of other things. The most remarkable is the live stuff. The material which makes it clot and go solid to stop a leak is called fibrin, and that is what holds the bodies of the Reds and Whites, that have died to save the whole machine, firmly in the leak. Isn't that



81. Reds stick themselves in to stop leaks in vessels like this man.

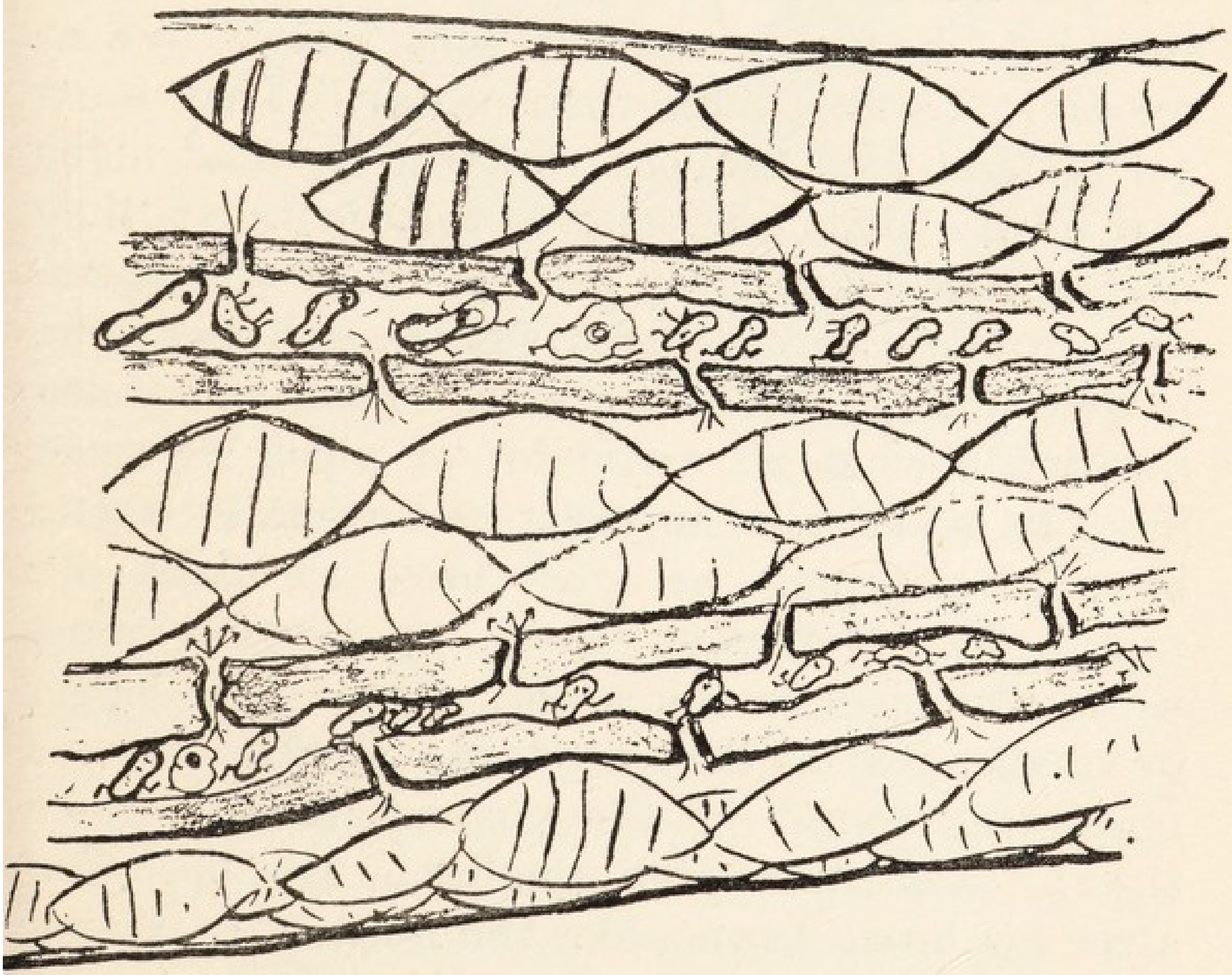
clever? It is like the man in the boat who saved it from sinking by putting his arm through the hole. (Picture 81.)

"This live blood stream is always in a hurry. It is as busy as the Great White Way, all day, all night, all the year round, without even Sundays off.

"Our blood is so valuable that there must be no leaks; and even the finest hair tubes have a wall one brick thick. So, really, the whole blood never touches any outside cell itself. It is like men living in a city who enjoy eating fish, but can never go and catch one. However, the tiny pipes or capillaries are so close together in some places that the distance between them is less than their own width. What is necessary is some middleman to get the food to the cells outside. This is called lymph. It finds its way out between the bricks in the hair walls, through holes too small for the Reds to get through. (Picture 82.) In this way every cell gets a sort of warm bath of soup all day and all night. This takes a great deal of lymph, almost three times as much as there is blood." (See Picture 80.)

"But how does the lymph get back?"

"Every time you move a muscle, or breathe, you squeeze it out of the spaces which end in openings into special little vessels. Valves keep it from ever getting back. So on and on it has to go into a large pipe, which empties at last into the blood through a big vein in the neck near the heart. It is pushed on also a little by the heart, and sucked on by the current in the vein. Moreover, it is helped along by the fact that it is different in composition from the other fluids, and so passes out into any fluid next to it. This process is called diffusion. On the way through its tubes the lymph passes through factories called glands, which filter it, and refresh it, and send new young white corpuscles into it. In the legs and arms it gets poor, because the motors there use it like gas, and never give anything to it. The glands act like the oil-up stations. All around the food canals, stomach and intestines, the lymph spaces grab up rich, fat cells. Here the lymph looks like milk, so the spaces are called lacteals (lac means milk), and the lymph is called chyle. These vessels unite till they become one, and this finds its way into the thoracic, or chest, duct with the rest of the lymph, and into the great vein near the heart; and so, like the blood, it goes on around for ever and ever, as long as life lasts."



82. Whites and lymph get through, but not Reds.

CHAPTER XI

THE PUMP AND PIPES

"BUT, father, what makes the blood go round to all the cells?"

"I don't wonder you ask. That is a real job, isn't it? For, you see, the cells cannot live as we can, on meals three times a day. They must get air and food brought to them day and night and all the time. So long as they get that, they do not care where they are, and they will therefore grow outside the body just as well as inside, if you also keep them warm. Then you must remember what an awful lot of pipes we must have to reach all the cells, and what an awful heap of pumping we shall have to make our pump do. Moreover, ours are far the most wonderful pipes in the world. They grow bigger or smaller just as they are told. Central sends a messenger round in the current inside, which says: 'Contract—Get smaller.' He is called after his home town—like the Joneses in Wales, Jones of Carnarvon—Adrenalin, which means, near the kidney.

"How much piping shall we want? Oh, about twelve thousand miles of it."

"Twelve thousand miles! Why, father, you can never pump anything twelve thousand miles day and night for years."

"Can't you make an engine do it?"

83. "You cannot leave it like your bicycles, till they are all in bits."

"No. No ordinary engine of steel or iron could do it. For, you see, it must never stop. Not for one second. It must never stop at all during the whole long life of the body, even for repairing, or the body will die, just as air has to be pumped into the subways day and night, and engineers have to sleep alongside their engines. Yet it is done, isn't it? Don't you remember Granny lived to be nearly a hundred?"

"Whatever does it, then?"

"Can't you think? It is our hearts. For thousands of years no one knew that, and the man who found it out, Doctor Harvey, was thought to be a freak; and he died before he could prove it. Now, what can we make such a heart out of?

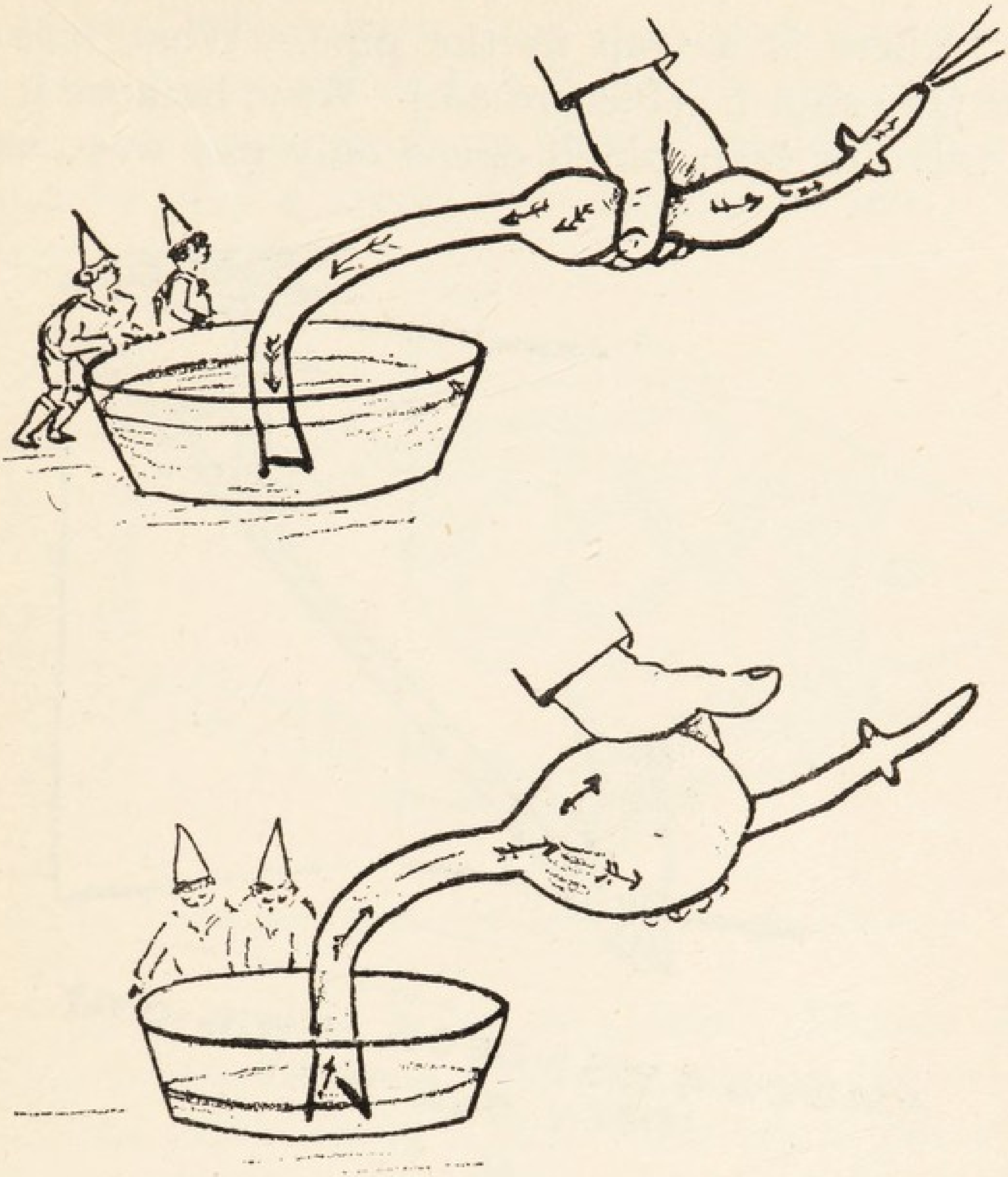
"Don't you remember when we were talking of motors, we spoke of cells with all the powers of striped and unstriped (red and white) muscle-cells, and yet involuntary or automatic. Even 'oak, ash, and thorn' or good pliant steel could not do all we need. We must get something that will repair itself; something alive and growing. It must not be like your 'bikes,' which will not work half the time because the wheel is warped with age, or the gearing gone wrong, or the rubber rotted. (Picture 83.) You cannot have your heart acting like that. You have got to renew it every minute that you live, and always have a new heart, all the time.

"Look at this syringe, what does it do? Pump water? Yes, but it cannot work by itself. What makes it throw the water along from this jar into the bowl?" (Picture 84.)

"Oh, that is because you are squeezing it."

"Well, you squeeze it, and see how long it pumps. See, now it stops and it has pumped only a teacupful."

"Oh, you must let it go as soon as you have squeezed it."



84. Be Sherlock Holmes for a minute—See how this works? Find how the two valves work.

"Why?"

"I don't know."

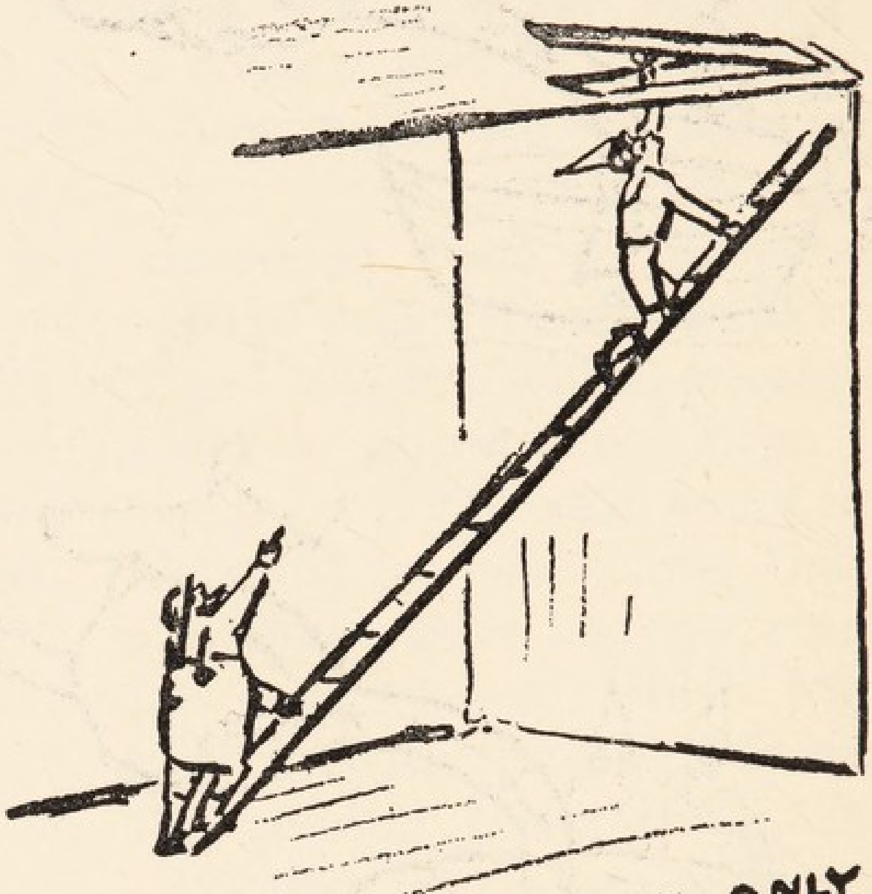
"Squeeze it again, watch carefully, and think."

"So as to fill the bulb again with water?"

"Yes, of course."

"But when you squeeze it, doesn't it go back as well as forward?"

"There is a trap in the pipe. What makes the trap shut? (Picture 85.) Why, because it is a valve or trap which opens only one way, and

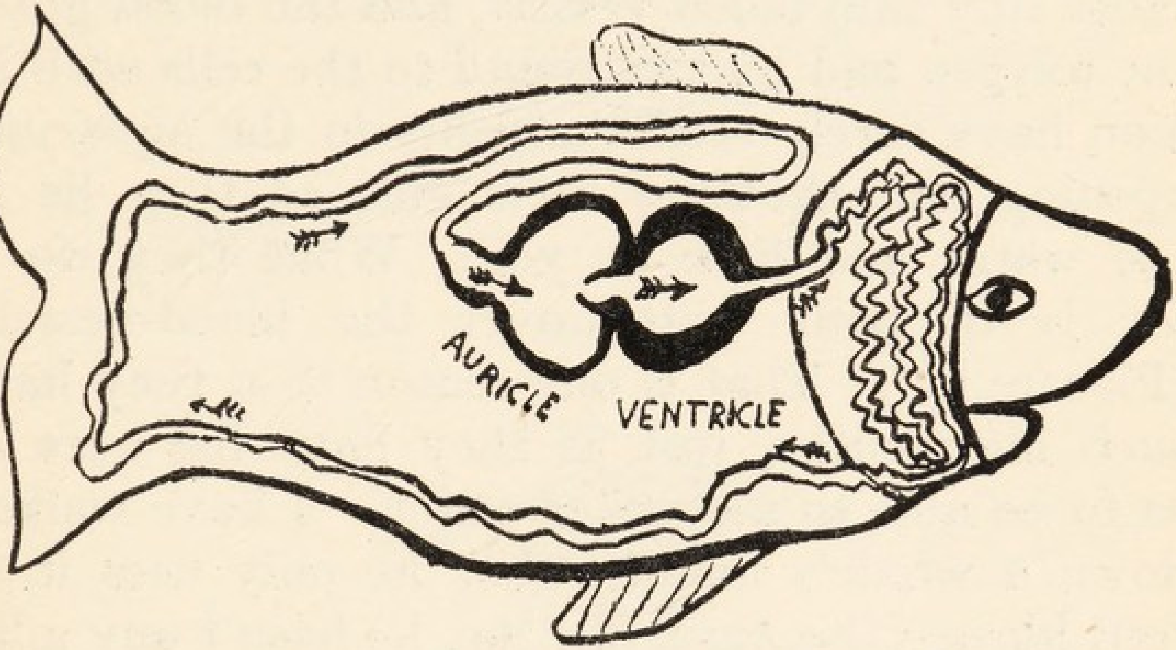


85.

the rubber, springing up again, sucks or pulls up the lid, and when you squeeze down, the lid closes again, kerplunk! It is exactly like the trap-door of our attic; and don't you remember the one we made to pump out our boat, with a wooden flap, a leather hinge, and a heavy coat of lead fixed on the trapdoor to shut it down. Doesn't that work well?"

"Splendidly."

"Well, the heart has invented far better valves for itself, and it has built two bulbs to make it throw stronger than it could with one, and to give a more even flowing current; not one that jerks.



86. A fish has a single heart with two chambers like ours.

"Look at this heart of a fish. (Picture 86.) You see two bulbs. One pumps into the other, and the clever thing is that while one is pumping blood along into the body, the other is sucking up more blood, so that it works both ends at once, and twice as well as our rubber syringe. Can you see how the heart is pumping blood through pipes into the fish's gills?"

"Why, yes. What is that for?"

"Can't you guess? To grab up oxygen from the water. (Picture 87.) Did you ever look at the gills of the fishes you caught in the lake? Did you notice anything inside the gills?"

"A lot of red fringes."

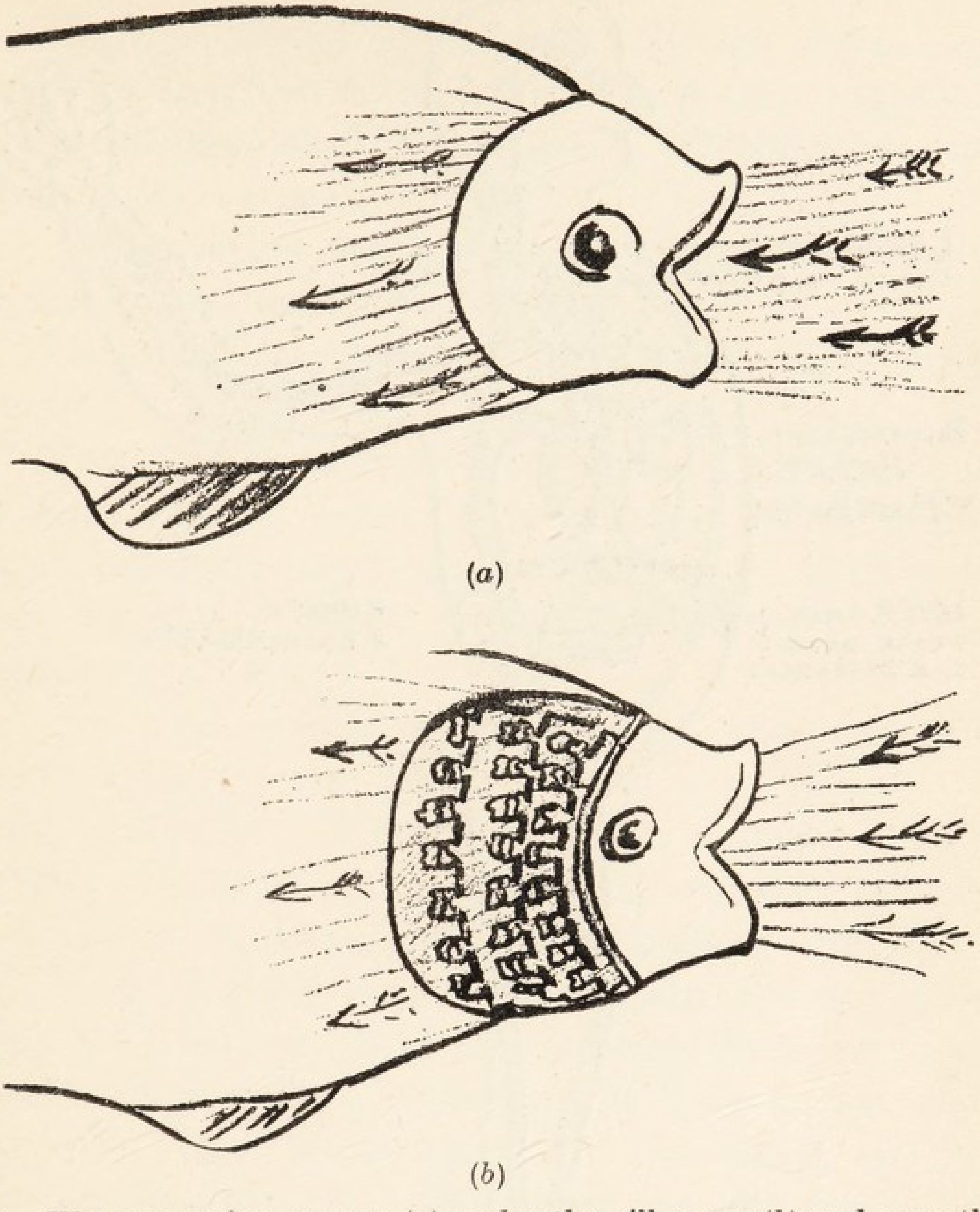
"What were those things, father?"

"Blood pipes, of course. The oxygen is in the water, and as the fish swims he opens his mouth and shuts his throat, and water pours in over those tiny thin blood-vessels, and the blood grabs the oxygen and hurries round to the cells with it. You have surely seen the fishes in the aquarium opening and shutting their gills as they lie in the water and look at you. What they do it for is to pour water over the blood-vessels. (Picture 87.) That is one reason that they have such big mouths, just as they have big eyes so as to be able to see under water. I have walked down a whale's mouth; but he only uses it to feed himself, because, like me, he hasn't any gills.

"The gills are really the fish's lungs. Occasionally I have seen human babies born with gill openings in their necks. You haven't got any, have you?"

"Oh, father!"

"Here is a picture of the best pump in the world—a good, stout old heart. (Picture 88.) You see, we must have something stronger than a fish's. They do not have to do half the work we do. Their food almost washes into their mouths, and they loaf around doing nothing but feed themselves. So we have two two-cylinder engines, as you see in the picture. One set pumps the impure blood into the lung, and the other pumps the pure blood into the body.

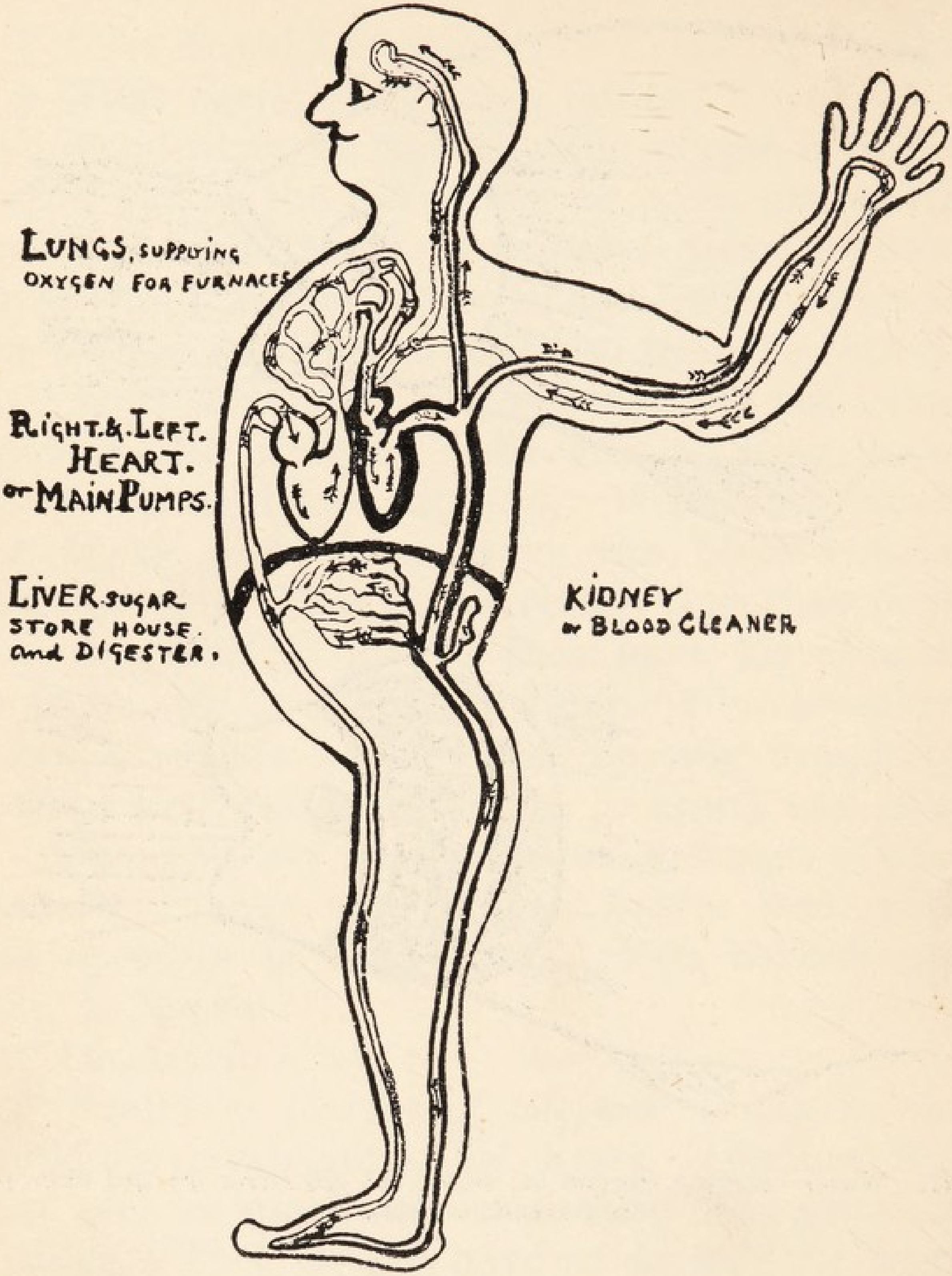


(*a*)

(*b*)

87. Water carrying oxygen (*a*) under the gill cover (*b*) and over the blood-vessels or fish's lung.

This pure blood carries the food and air. The pumps lie side by side and are joined together making a shape something like the ace of hearts. They throw twenty tumblerfuls in a minute, and all the blood in the body in one and one-half minutes. But if you run a race or climb a high



88.

mountain all the blood in your body may pass through in one minute. The first pipes are large and are called arteries, or 'air thoroughfares.' Then they get smaller, and smaller, and smaller, like Alice in Wonderland, till they are mere hair tubes, or capillaries, and then these join together and get bigger and bigger again, till they are the pipes called veins.

"The arteries are strong and thick and very elastic. Can you guess why?"

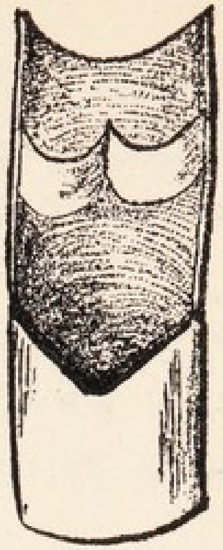
"Because the heart pumps hard right into them?"

"Yes, that is part of the reason. But there is another, and a very clever reason. You know those squeaker toys with elastic bags that you blow up, don't you? What makes them go on squeaking so long?"

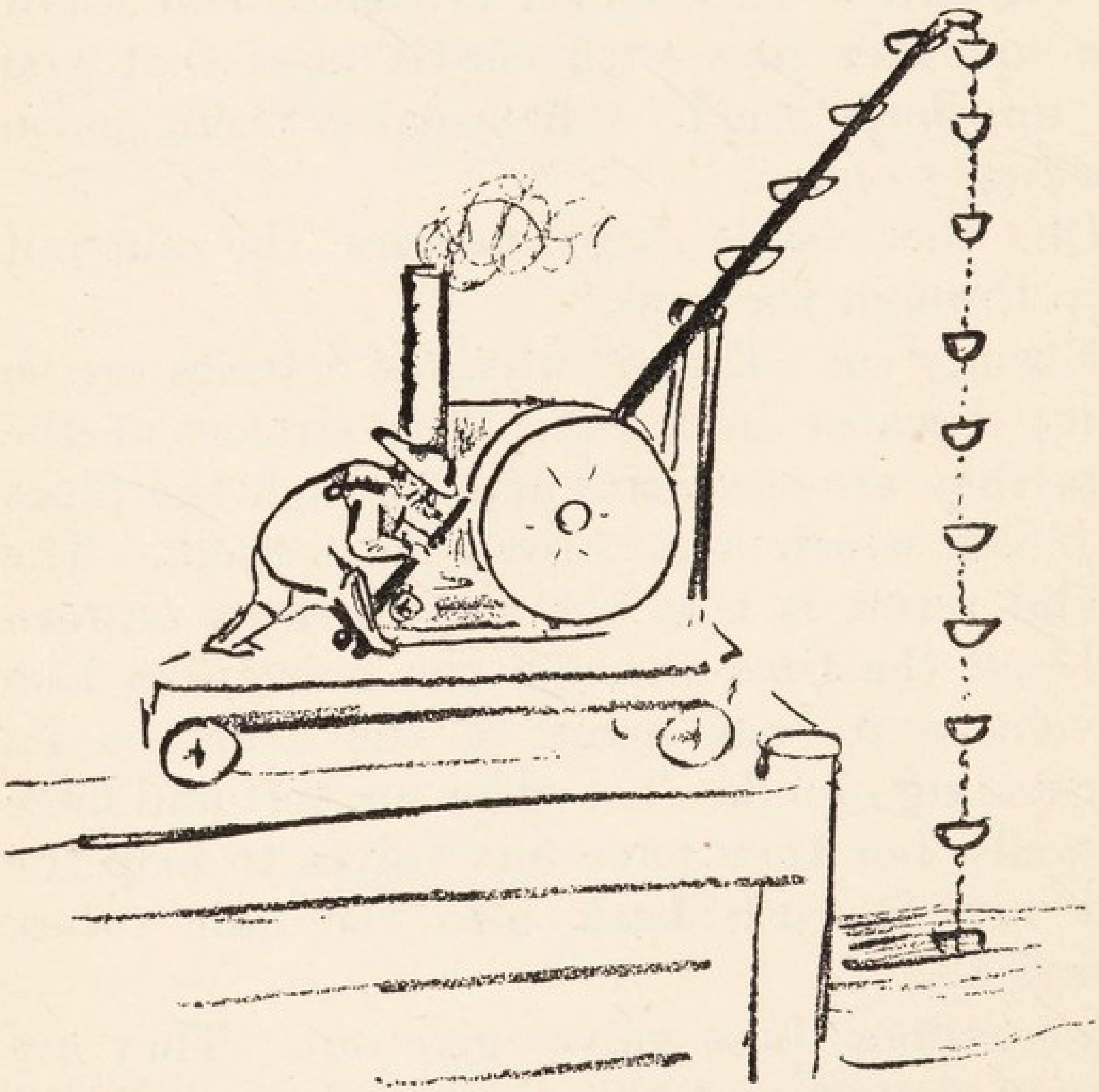
"Oh, the elastic bag squeezes the air out slowly through the pipe."

"Exactly so. That is why the arteries are so elastic; because in between the strokes of the pump, they are squeezing out through the pipes the blood which was forced into them. The splendid result is that the stream flows onward evenly all the time through the hair tubes into the veins and back again to the heart on its never-ending round. The veins are soft and have thin walls, but they have fine valves to help the blood not to rush back into the hair tubes. (Picture 89.)

"Sometimes those valves give out. They are not very strong, and they have a heavy weight on them if they happen to be in the legs of a fat person. (Picture 90.) Then what happens is this: the blood does run back, and leaks out

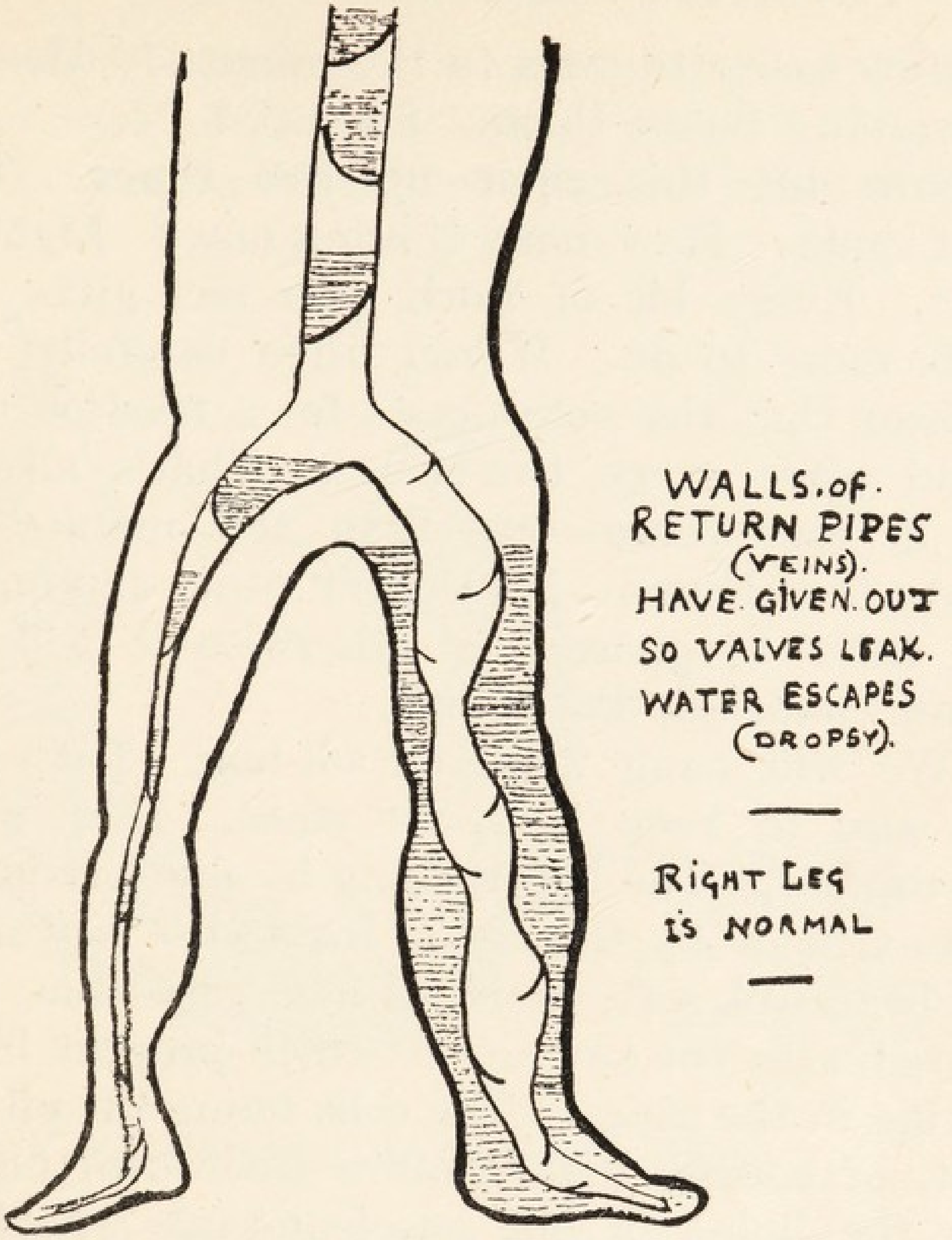


The valves in the veins.



RAISING WATER IN CUPS LIKE VALVES OF VEINS

89.



90.

everywhere, and the legs swell up and turn blue and hurt, and the poor man cannot get his boots on.

"Where is your heart? Can you feel it?"

"Surely."

"What is it doing?"

"Thumping."

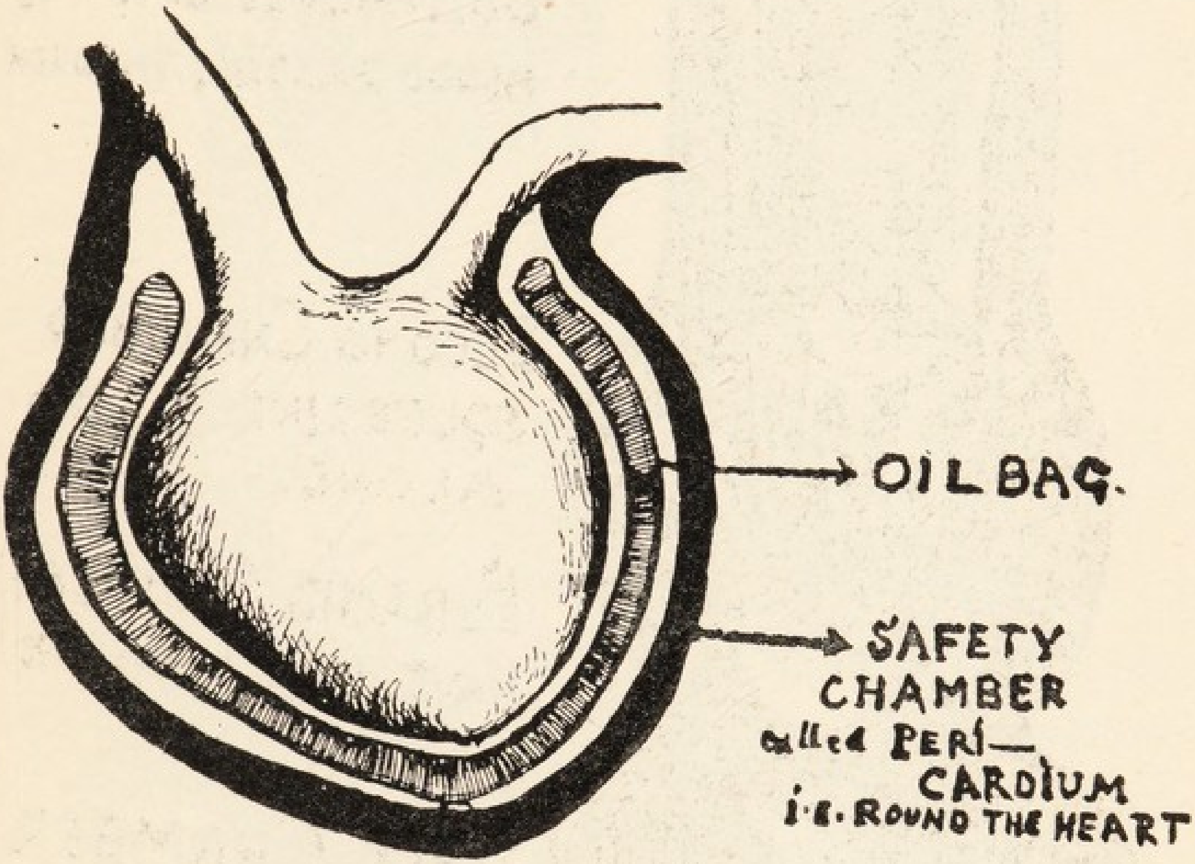
"How many thumps to the minute? Here is my watch. Count them. Seventy?

"Now lift this chair up five times. Now count again. How many thumps now? Eighty? Right. Every bit of work, you see, gives our hearts more to do. If you listen carefully you can hear that the pump rests for a fraction of a second after every two beats. That's all the rest it ever takes—less than ten minutes in twenty-four hours. Like every other pump, we shall have to grease it; otherwise it will get hot and jam, like the engine.

"We will hang it in an oil-bag. That will help also to keep it in its place. Here it is. (Picture 91.) The bag is slung by fine ties inside the box made by the ribs. Inside the bag there is a beautiful soft, moist lining, very thin, and covered with the same cells which prevent blood clotting in the pipes. The cells lining the oil-bag must, of course, manufacture their own oil. I wish the lining of our gasolene-tank would do likewise.

"Every dog has to have a name to tell it from other dogs, and all these parts of the body have Latin names or Greek ones. They are very easy if you know Latin and Greek. But we do not really need them.

The big pipes which are elastic remain open and are full of air after the body is dead, because, of course, the elastic has squeezed all the blood out of them. But that made doctors think that they always carried air, and so they called them ‘air-teries,’ and we still call them by the old name; just as the first bulb of the heart is called



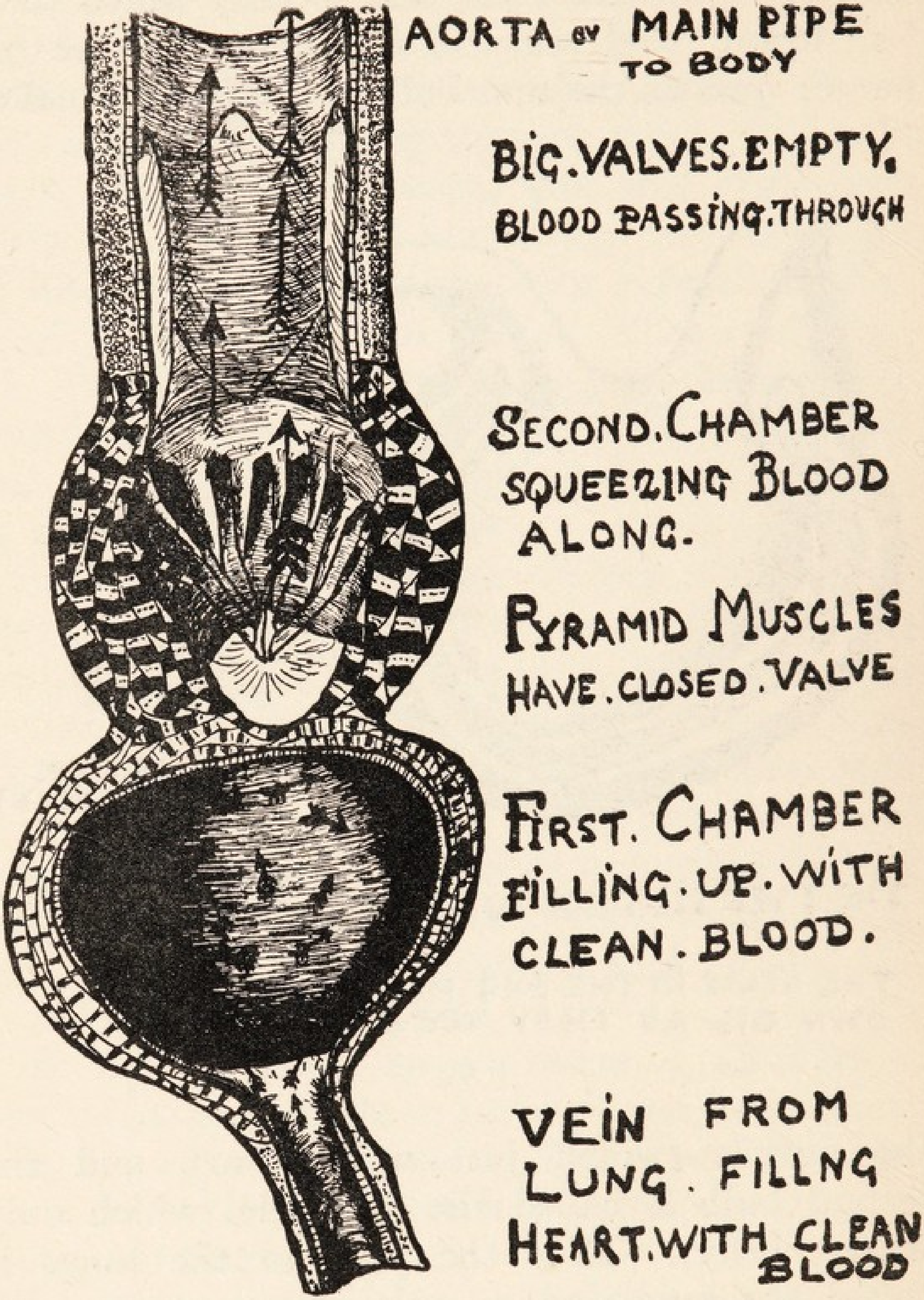
THE TWO HEARTS IN ONE OIL BAG.

THE CELLS IN THE BAG MAKE THEIR OWN OIL AS THEY NEED IT.

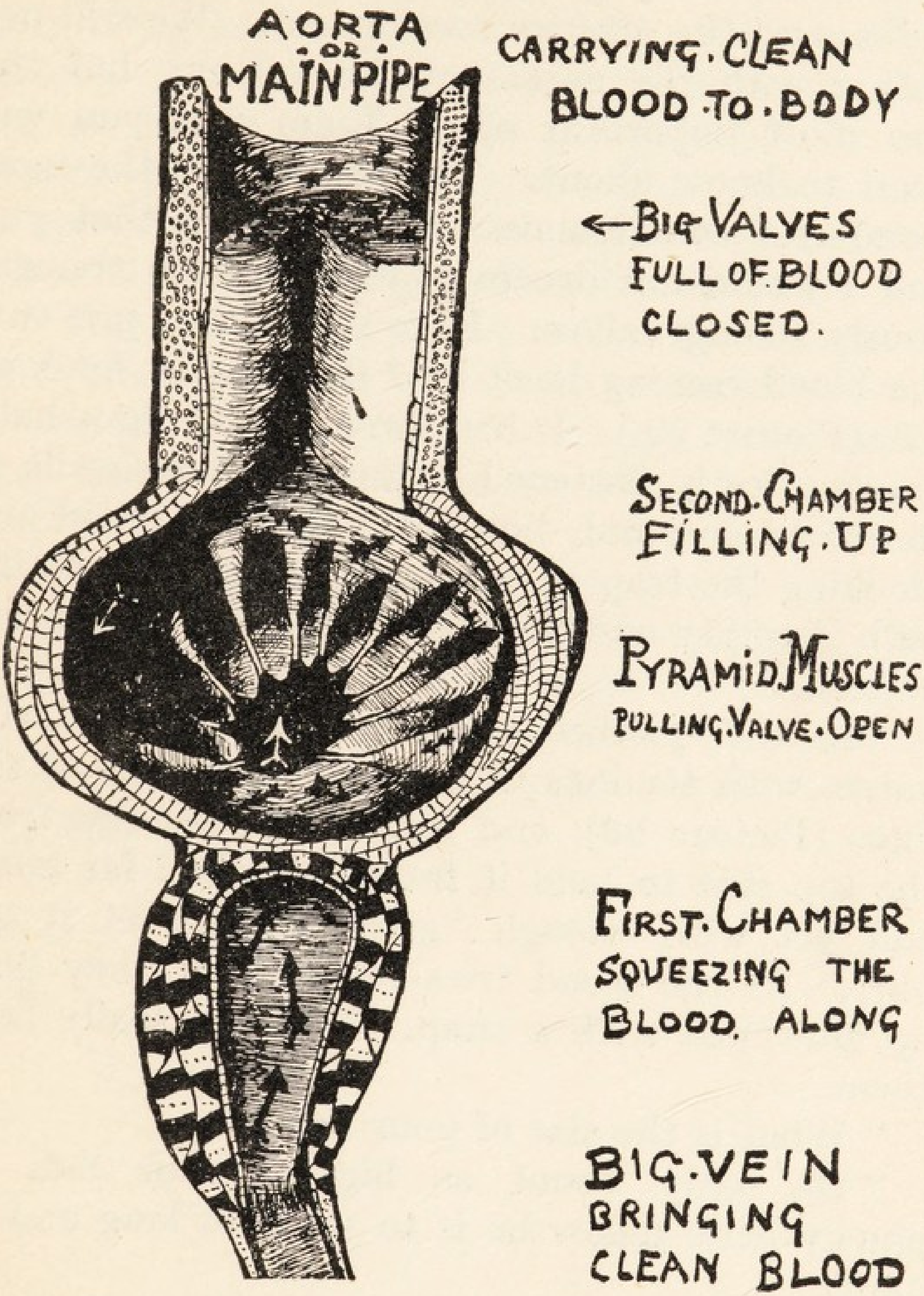
91.

the auricle (which just means ear), and the second bulb is called the ventricle (which only means belly). Thus the pipe to the lungs is called the lung-pipe or pulmonary artery; and the pipe that carries blood to the whole body is called the aorta, or carrier.

“You can see the veins from the lungs and the


AORTA or MAIN PIPE
TO BODY
BIG. VALVES. EMPTY.
BLOOD PASSING. THROUGH
SECOND. CHAMBER
SQUEEZING BLOOD
ALONG.
PYRAMID MUSCLES
HAVE. CLOSED. VALVE
FIRST. CHAMBER
FILLING. UP. WITH
CLEAN. BLOOD.
VEIN FROM
LUNG. FILLNG
HEART. WITH CLEAN
BLOOD

92.


AORTA
OR
MAIN PIPE
CARRYING. CLEAN
BLOOD. TO. BODY
←BIG VALVES
FULL OF BLOOD
CLOSED.
SECOND. CHAMBER
FILLING. UP
PYRAMID. MUSCLES
PULLING. VALVE. OPEN
FIRST. CHAMBER
SQUEEZING THE
BLOOD. ALONG
BIG. VEIN
BRINGING
CLEAN BLOOD

93.

rest of the body going into the auricles, or first bulbs, and the arteries coming out. We will not bother with the names of the valves; but the two most important of all I am sure you will want to know about. They really are the most wonderful contrivances. I am afraid that you and I would not dream of making such tremendously strong valves. Here is one that prevents the blood coming back into the heart. Look at it. (Picture 92.) It has three stout fibrous half-bags perfectly flattened against the pipe walls as the blood goes out, but filling up with blood and blocking the trap or entrance just as soon as the bulb is empty and the elastic pipes try to squeeze it back.

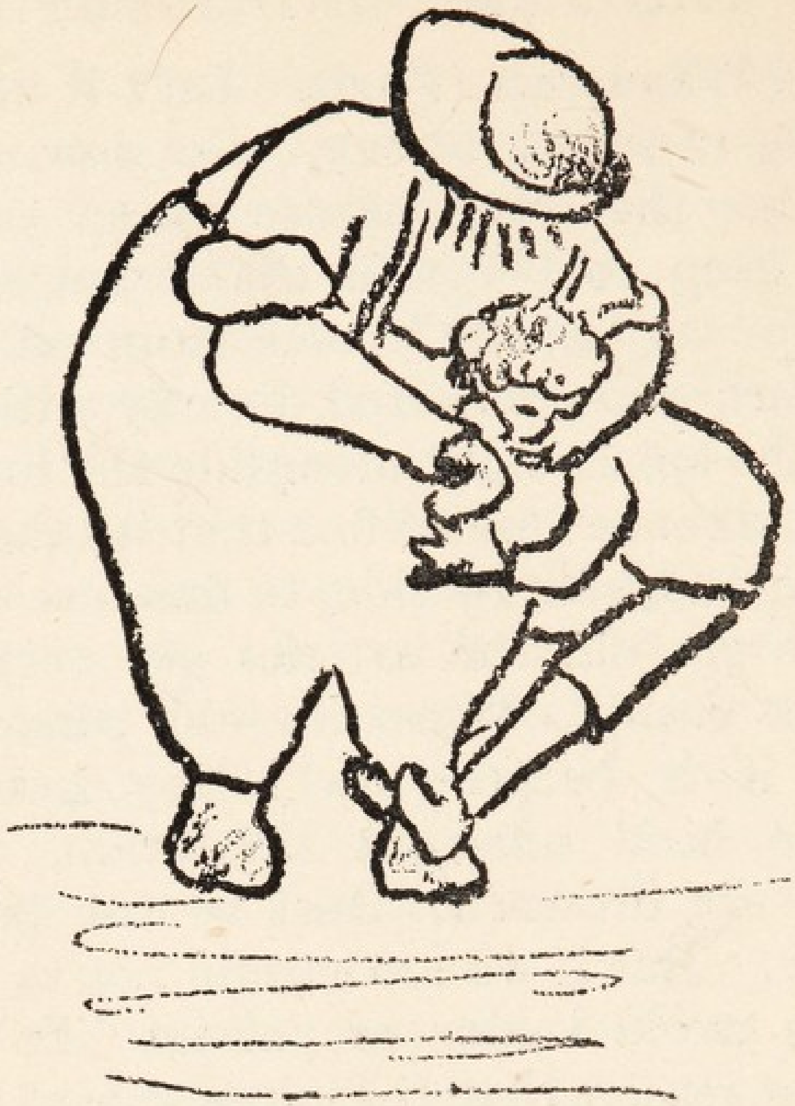
"In this picture you see another wonderful valve, with tendons or ropes to the edges of the flaps (Picture 93), and little fairy muscles from the top side to hold it from going too far back, and yet with enough 'give' not to let it get hurt. As the blood tries to get back they float up and close with a snap. You can easily hear them.

"What is the size of your heart?

"Oh, only about as big as your fist. A plucky little fellow he is to work so long and so hard.

"For the heart's guidance local offices exist, both in and on its walls. Some messages come direct by special wires all the way from the central office in the brain. These long wires are called the Wanderers (*Vagi*). Isn't it odd, these only bring messages to say, 'Go slow, brother,' exactly like the slang phrase 'keep your shirt on,' or 'keep cool'? All the messages to say 'speed up' or 'hustle' come from offices close to the heart, and connected directly with the big wires in the spine, right alongside the heart.

"The hair tubes are so fine that it takes two to three thousand, side by side, to measure one inch. As people get old the arteries get very chalky and break easily. When an old person has a 'stroke' it is because an artery has broken inside the head office in the brain, and the managers are drowned. Just so the body dies eventually. But if we are careful not to overeat, and if we avoid toxins or poisons like alcohol, there is no reason that the pipes should not last a hundred years easily."



94. "We wash them."

CHAPTER XII

THE FURNACE HOUSE

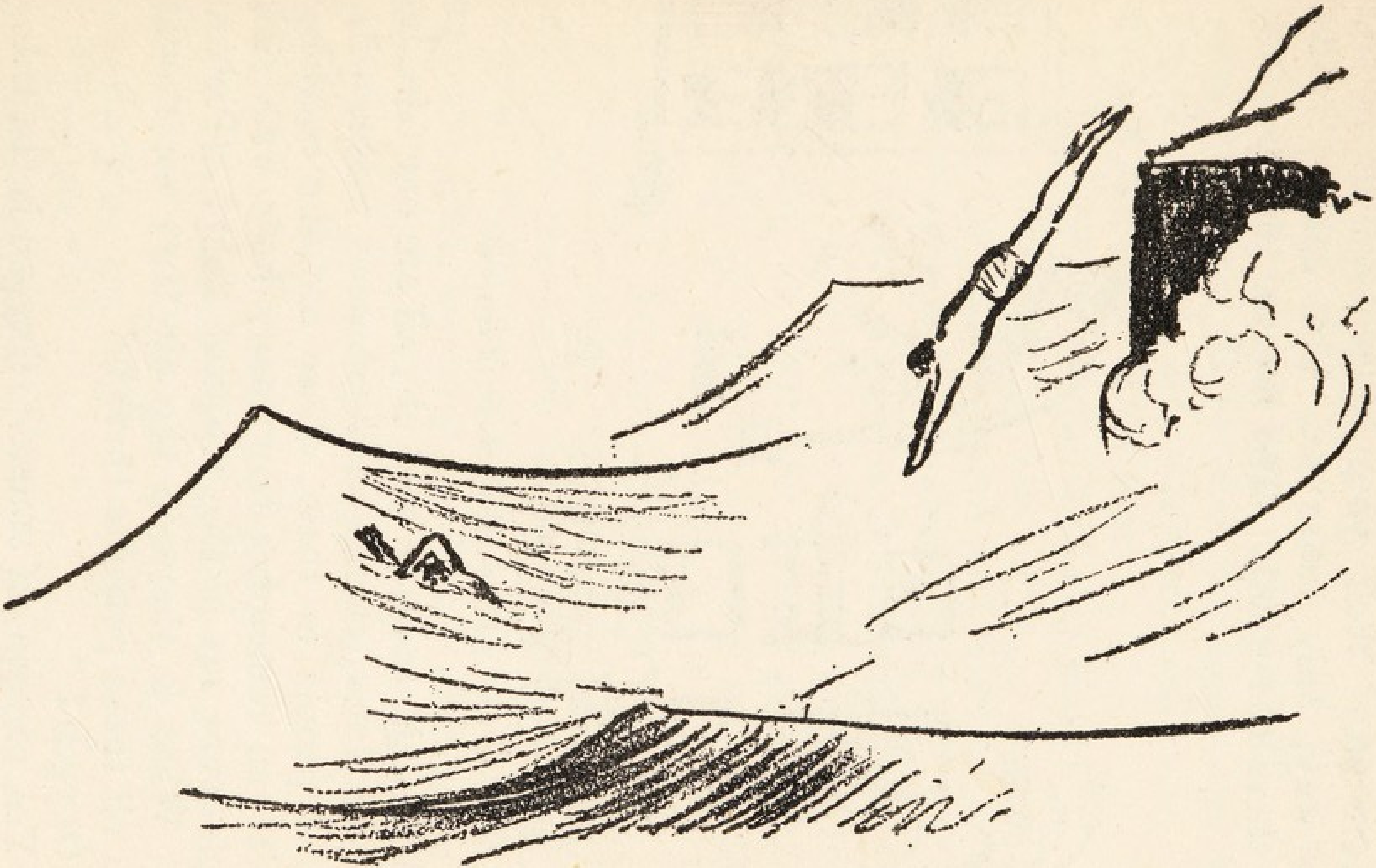
"How does the air clean the blood, father?"

"How do we clean most things?"

"We wash them." (Picture 94).

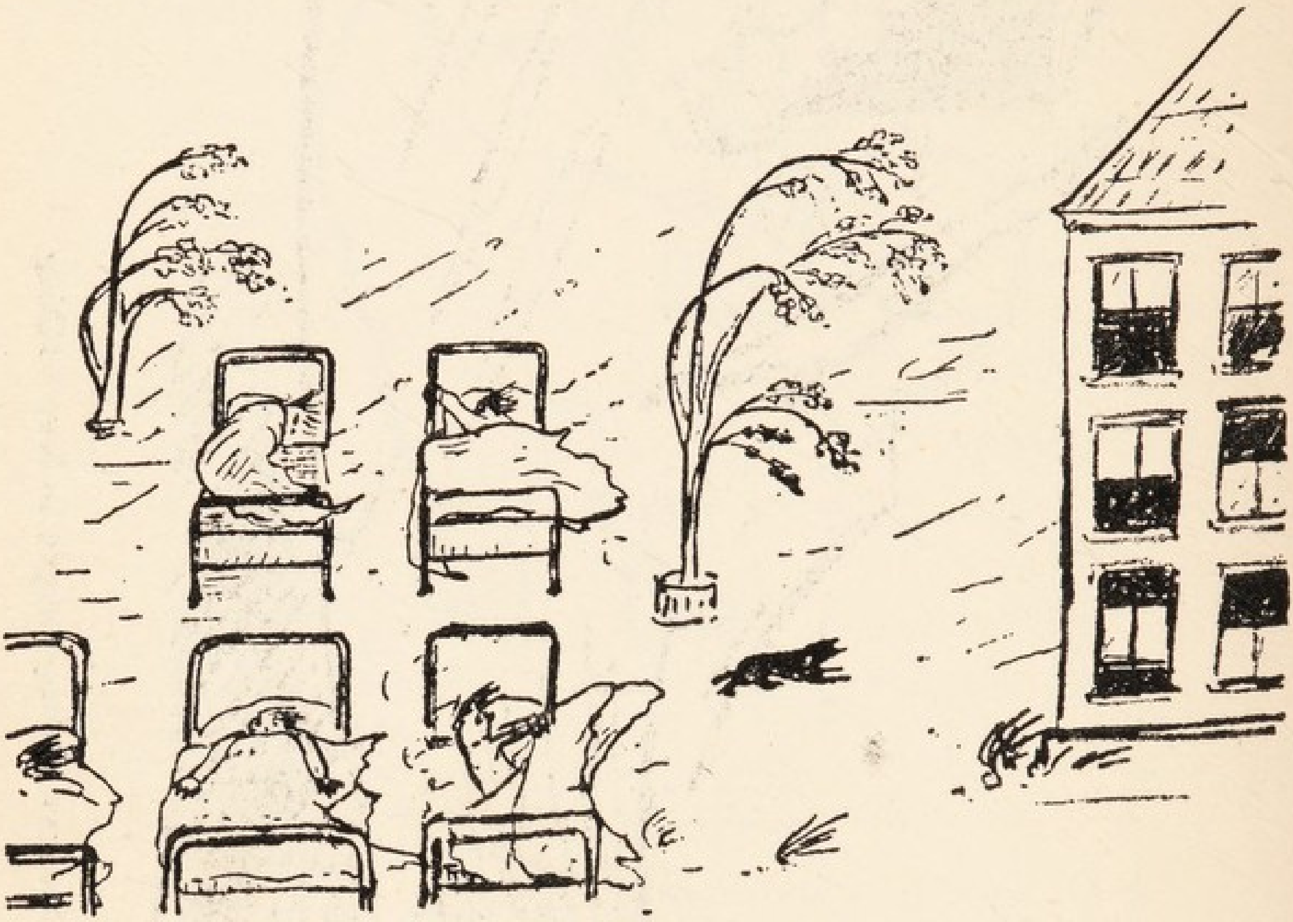
"But how can you wash anything with air?"

"You bathe it in it long enough, of course. Our bodies teach us naturally to love bathing. Don't you just live in the water in summer?



95. Nature teaches healthy people to love bathing.

(Picture 95.) Well, your lungs love air in the same way, only more so. You cannot really give them too much. The breeze, the open air,



96. Sick people need lots of fresh air.

the fresh air, and the cold air, all are our friends. Shut windows, closed or overheated rooms with lots of people in them, those are our enemies. Don't you remember how many beds with sick people were out in the hospital field? (Picture 96.) What is there in the air that we should keep all those patients there?"

"Oxygen?"

"Yes, oxygen, of course. Oxygen is the thing that keeps things alive by burning up all the poisons. How do I know it? Just let me show you. Do you see that bottle? Is there anything in it? Only air. Now blow out this match and dip it in the flask. (Picture 97 *a*). See what happens. It catches fire again and burns brightly? That was oxygen, not air. Only oxygen can make it do that.

"Can you see anything in this glass?"

"No. Nothing but air."

"Put this lighted match in. See how it burns just as it does outside. (Picture 97 *b*). All right, keep it there. You see, it is going out. That was just a bottle of air, and the oxygen is now burned out, so that the match goes out, too. Now hustle up and dip it in the oxygen bottle again."

"Hurrah! See how it blazes!"

"So you see what we want to do is to dip the blood into the oxygen in the air and wash it well with it. Only our laundry must go on all day and all night, washing our blood with fresh air, because only one-fifth part of air is oxygen."

"Do you mean breathing, father?"

"Yes, I do."

"But can't we hold our breath?"

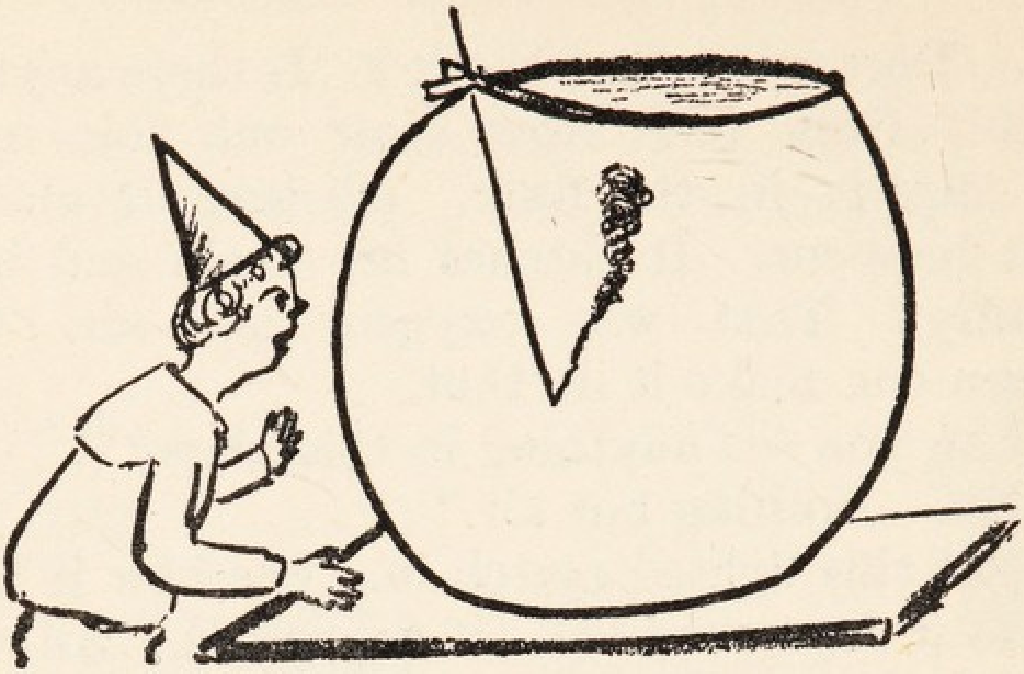
"Try and see for how long you can stop breathing. Good! Three-quarters of a minute. But why do you pant so?"

"I've got to."

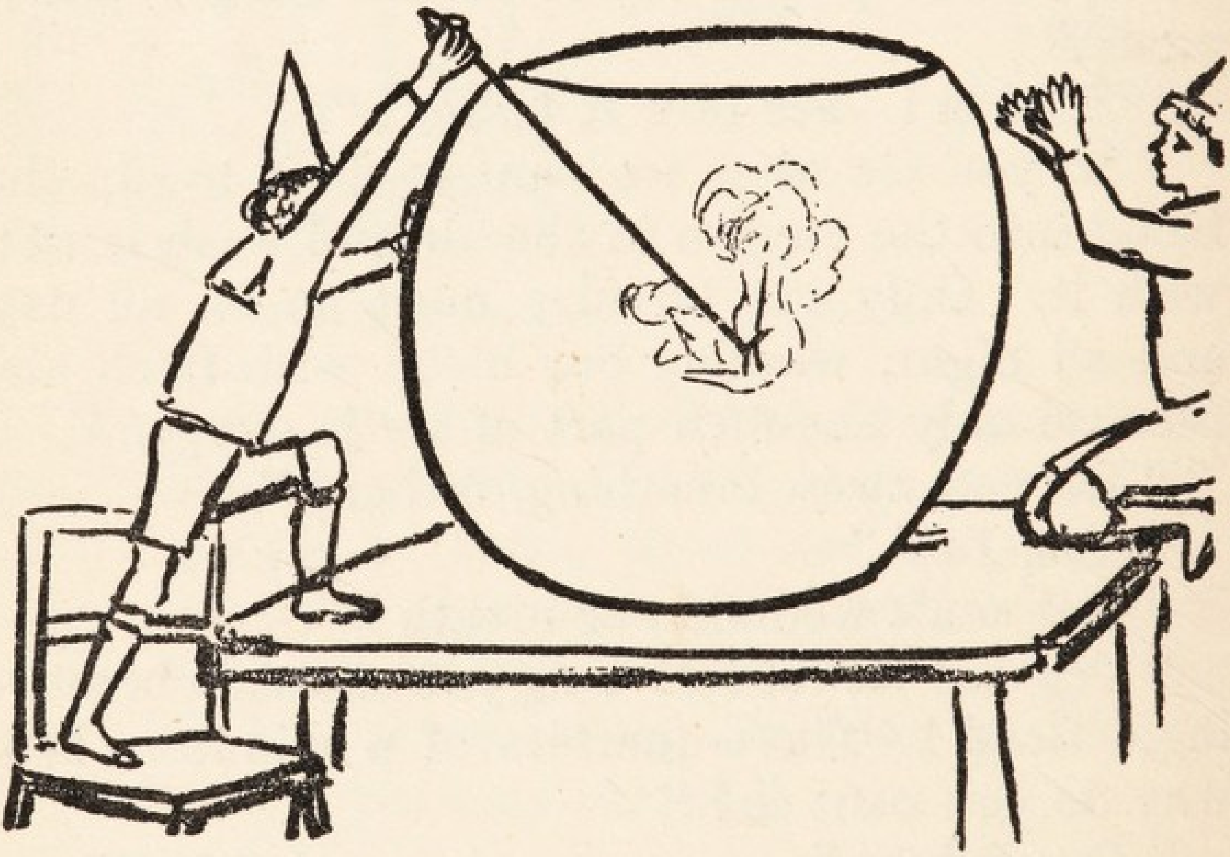
"Who told you to?"

"No one. I just can't help it."

"What is making you do it?"



97. (*a*). The match has gone out because the oxygen is burned.



97. (*b*). It has come alight again because the bowl is full of oxygen.

"A feeling inside."

"Some one calling out, eh? Who can it be?"

"Is it the blood?"

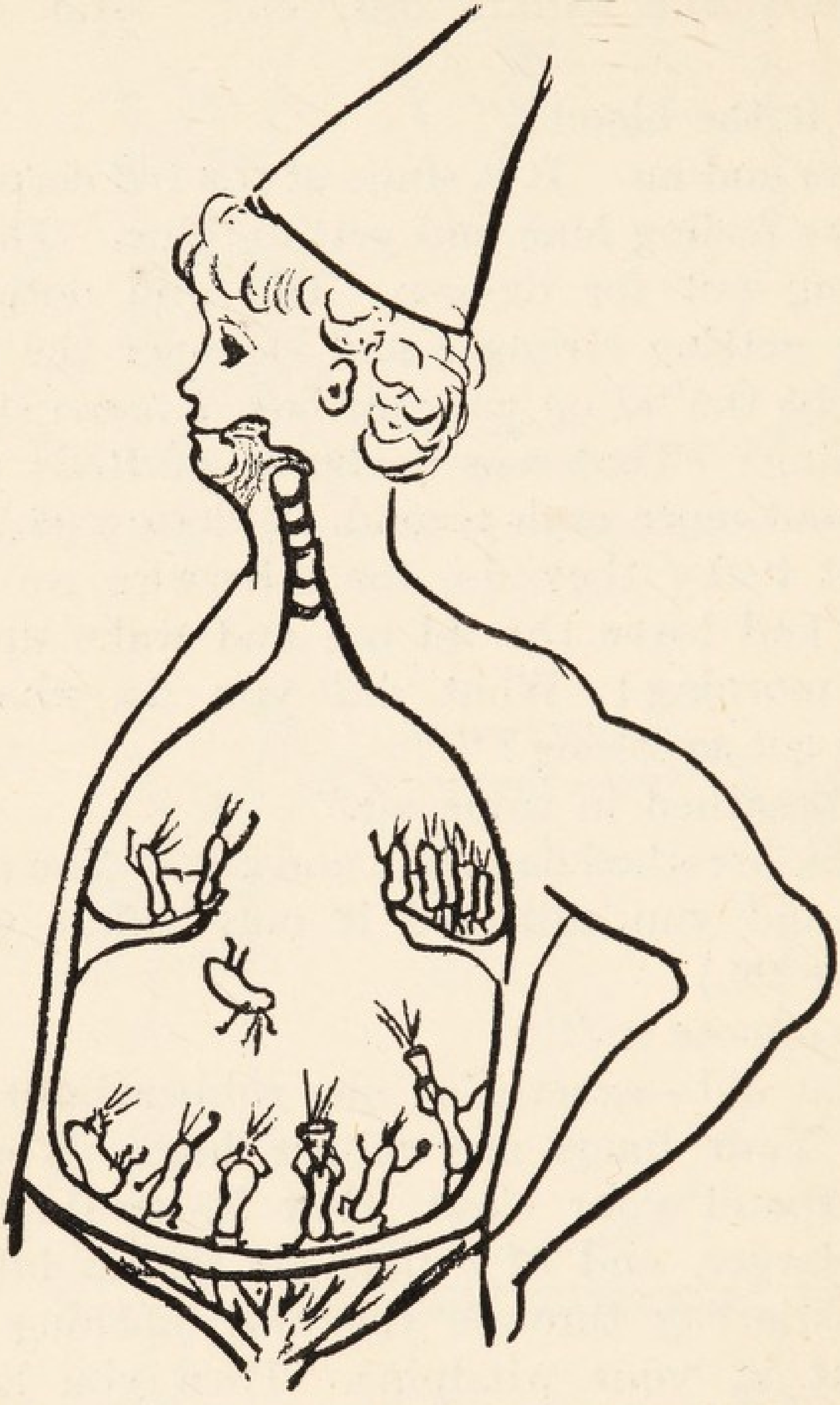
"Yes and no. It is some of the red corpuscles, who are feeling blue and getting blue. They are shouting out for oxygen. Did you notice the feeling getting stronger and stronger the longer you kept the lid on your air-box, I mean stopped breathing? That was a chorus of Reds yelling more and more each second. (Picture 98.) But isn't it lucky they do, for otherwise we might forget and leave the lid on, and wake up dead some morning! What did you do when the feeling got so strong?"

"I breathed in some air."

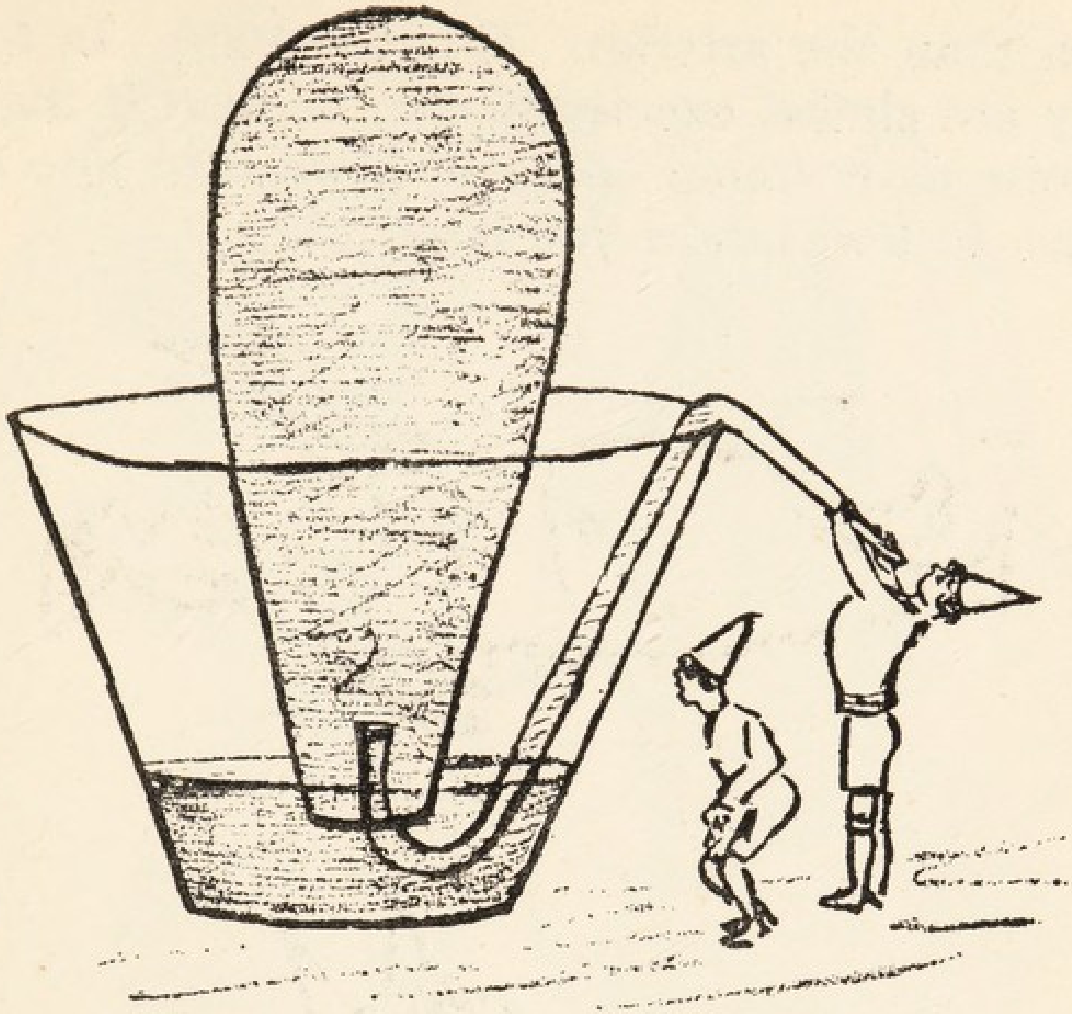
"Yes, breathed deeply in and out. You sucked it in, and you squeezed it out, didn't you?" (Picture 99.)

"I suppose so."

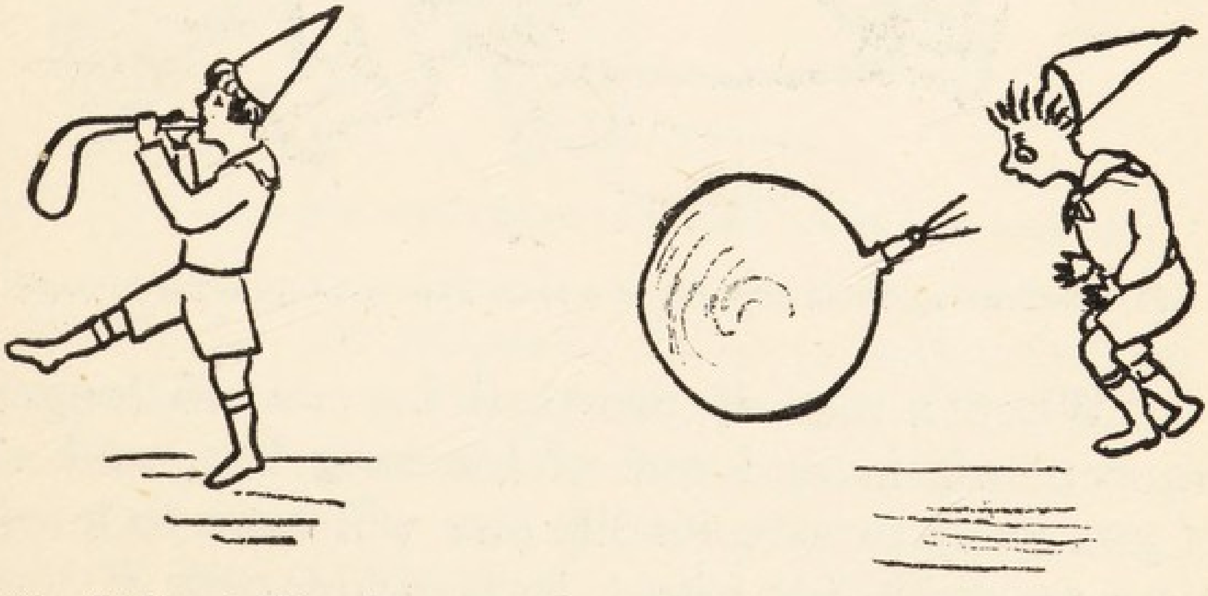
"You did—exactly as our rubber bulb-pump does. Your lungs are rubber bags. You see, you expand your chest, that is, you make it much larger, and of course air rushes into the big elastic bag through the only opening there is, that is, your windpipe. Then you let the weight of your arms and body squeeze it out. The reason for having the bags made of elastic is that they can do enough squeezing out themselves, even while we sleep, if everything is O. K. They are more like the elastic bag squeaker



98. It is the red corpuscles that are getting faint and blue that call for more air.

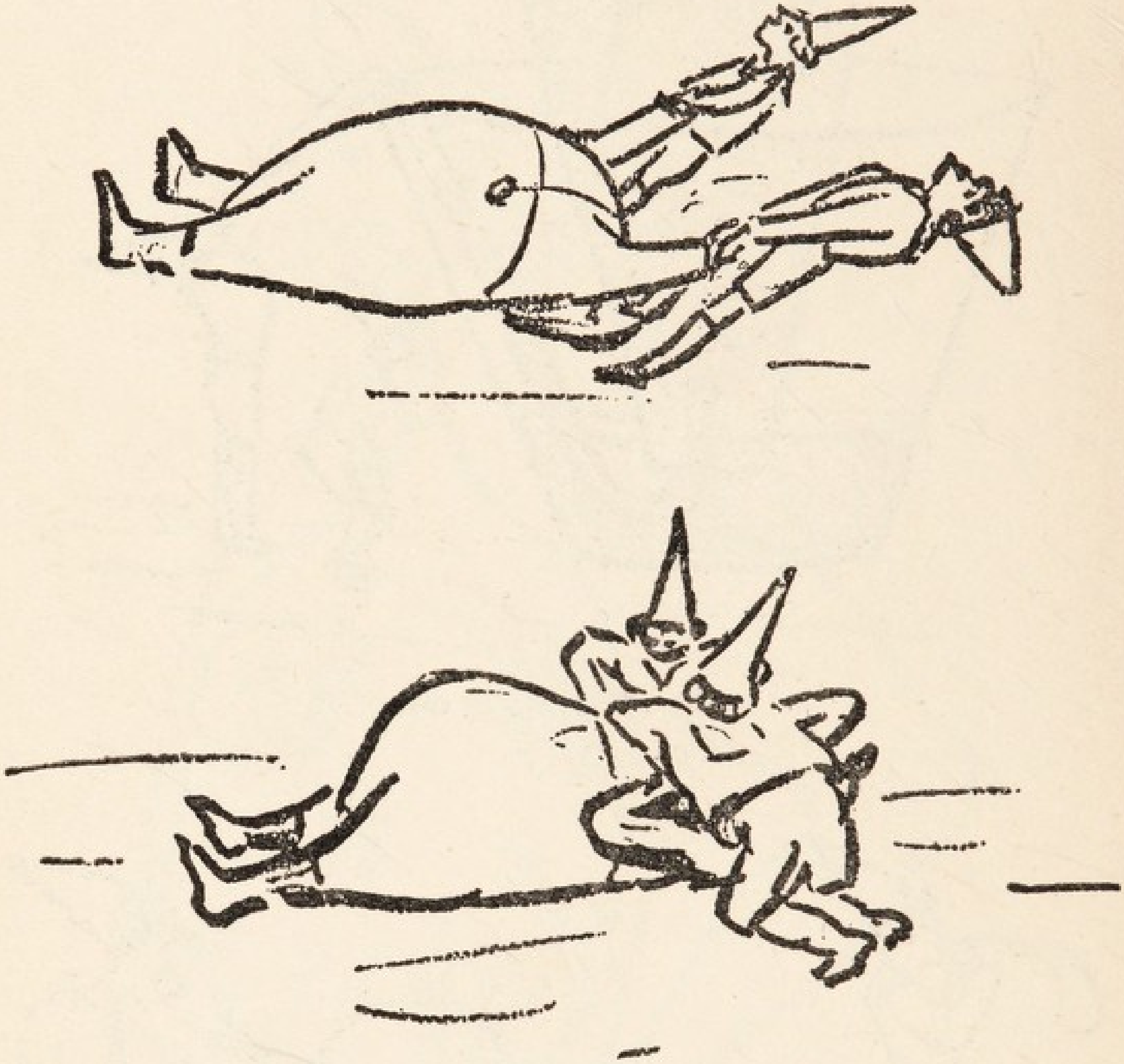


99. Forcing in air.



100. It is only the air you put in coming out again because the bag is elastic.

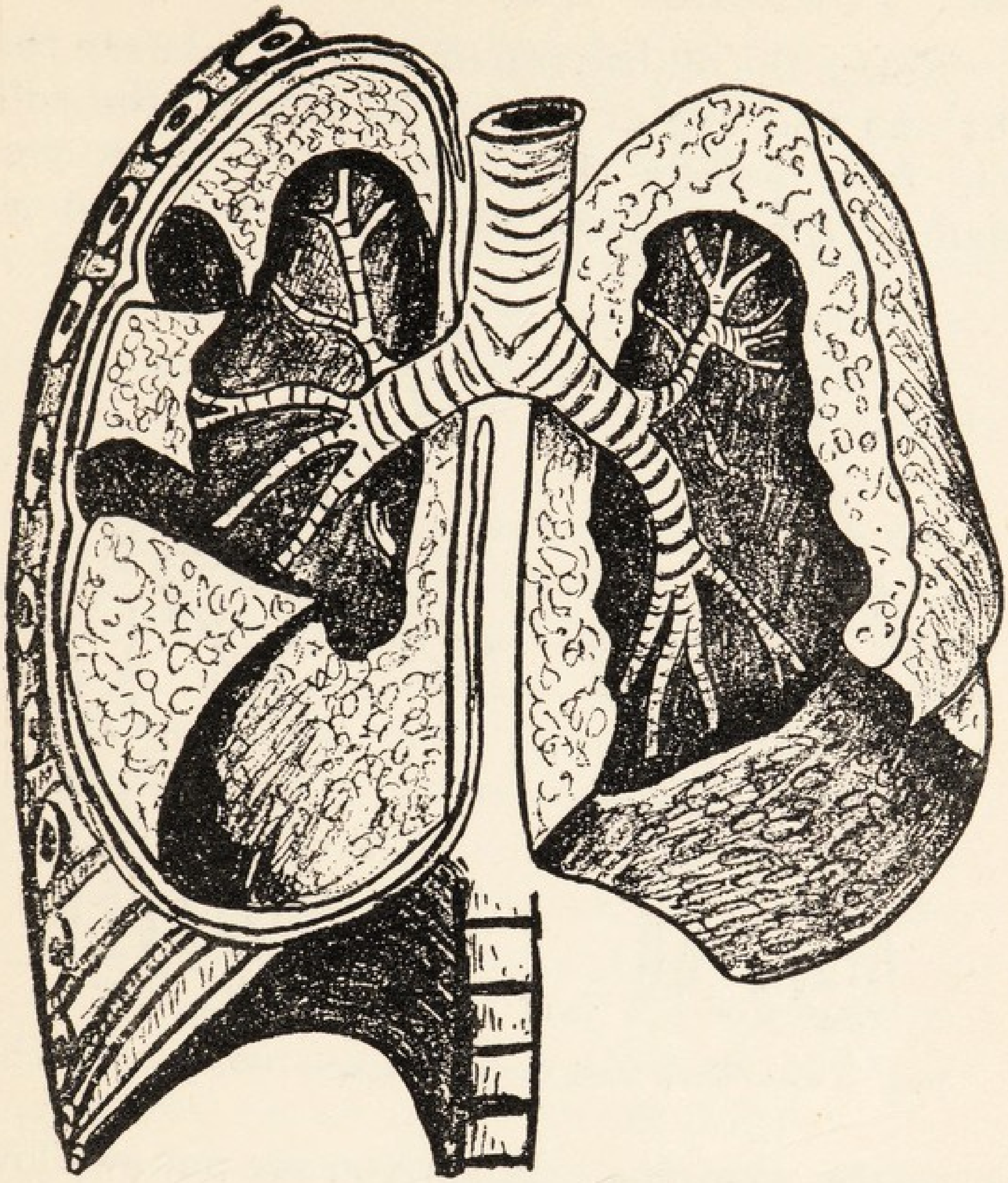
even than the arteries. (Picture 100.) In fact, they are almost exactly like it, because it makes a noise as it comes out, which we turn into our voice, as I will show you later.



101. Squeezing air in and out of a man who can't do it for himself.

"When a man is drowned he can no longer squeeze air in and out of his lung bag, and so if you want to save his life you will have to know how to do it for him. It is quite easy if you know how. (Picture 101.)

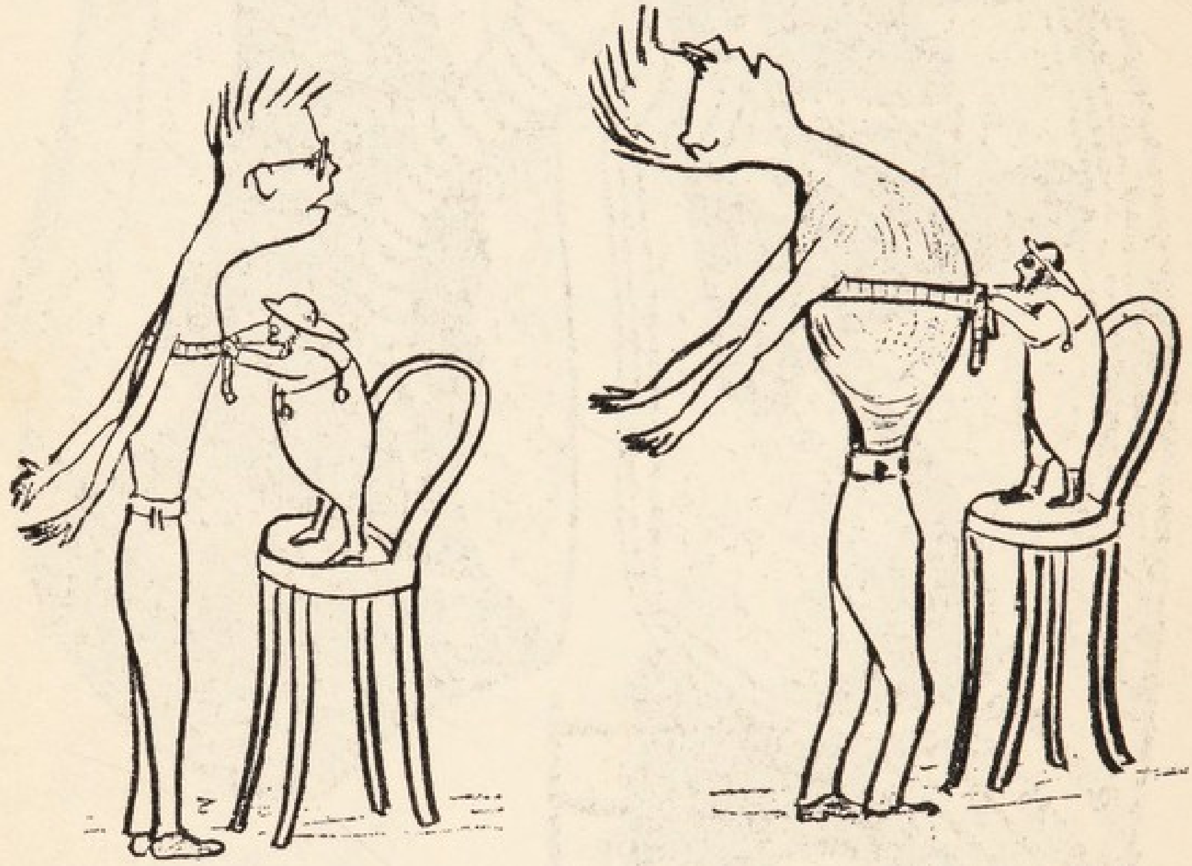
"How does the chest expand? That, too,



102. This is exactly what our air-pipes and breath bags look like.

is simple to understand. It is a real chest or box made of a bony framework. The sides are filled in between the frame pieces with flat layers of muscles, and the top and sides also. (Picture 102.) The top has one hole through it, called the windpipe. There is a lid to the pipe which is fast to the back of the tongue.

"Notice the oil-bag full of dark oil between the ribs and the bag of rubber to prevent the soft lung from getting chafed or hurt. When you swallow, the lid closes, so that no food can go



103. A man with a chest like a champagne-bottle is no good.

down the windpipe. When you are not swallowing, it is always open, and air goes in and out easily.

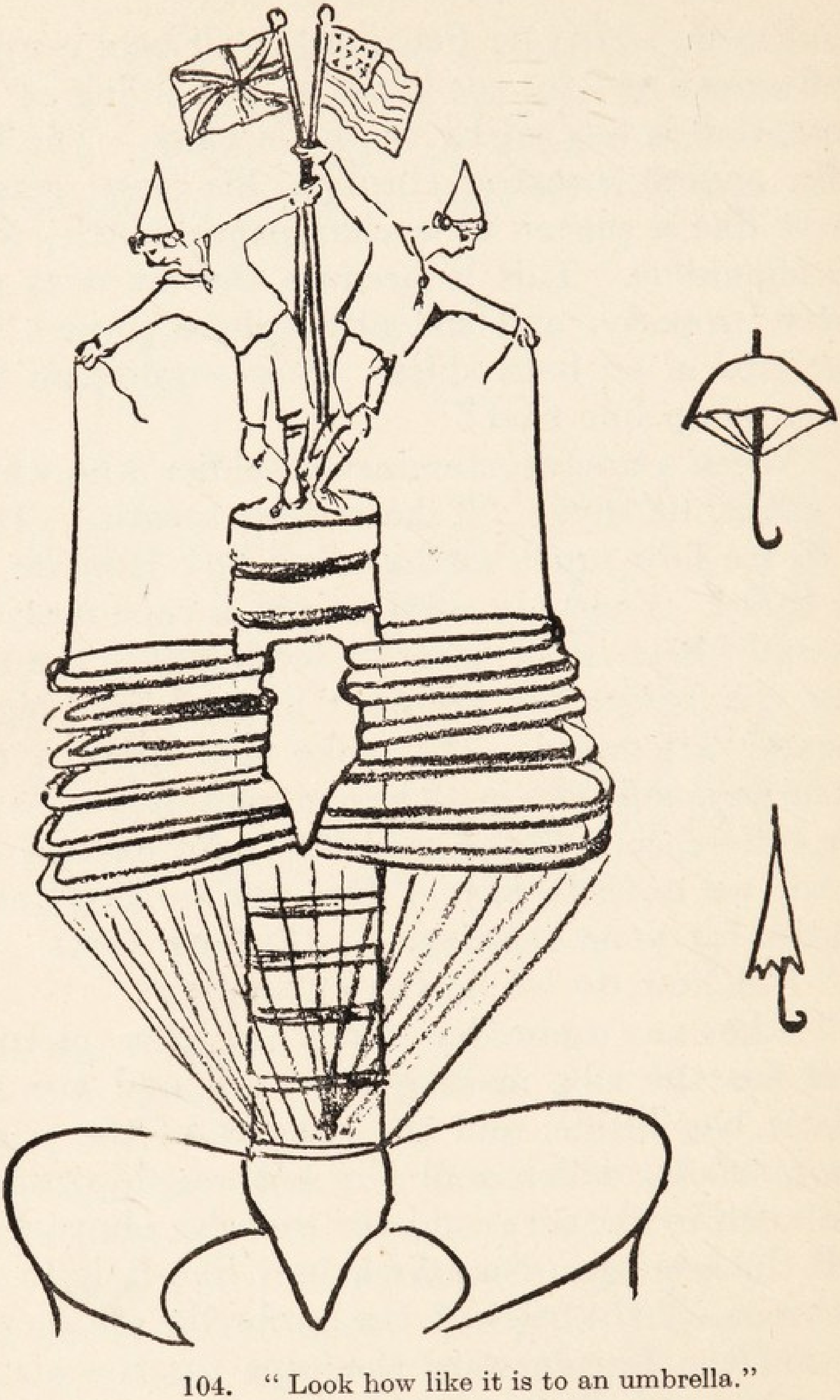
"When the mouth is shut, the soft curtain at the back of your throat is closed. Only the nose stays open. The bony rings around the pipe are to keep it open. Here the lid of the air-pipe is open. Air is going in easily. (Picture 102.) Here, you also see, is the right way to breathe—not through your mouth, but through your nose. Why? Because the air gets warmed and moistened by the pipes in the lining of the nose, and is filtered by the little hairs. The boy who cannot breathe through his nose gets a chest like a pigeon or a champagne bottle, with no shoulders. This is because the air does not enter properly, and the atmosphere presses the soft ribs in on both sides. How would you like to grow up like that?

"When a doctor examines a soldier who wants to enlist, he says: 'Take a deep breath.' That is to see how much air he takes in. How do we do that? You only need to put a tape-measure around his chest in order to see how big the air-box was before the air went in, and how big it became afterward. We make him breathe out all he can, and then in all he can, and thus measure the difference. If the recruit cannot expand his chest, we have to say: 'You are no good as a soldier for your country.'" (Picture 103.)

"But how do we do the expanding?"

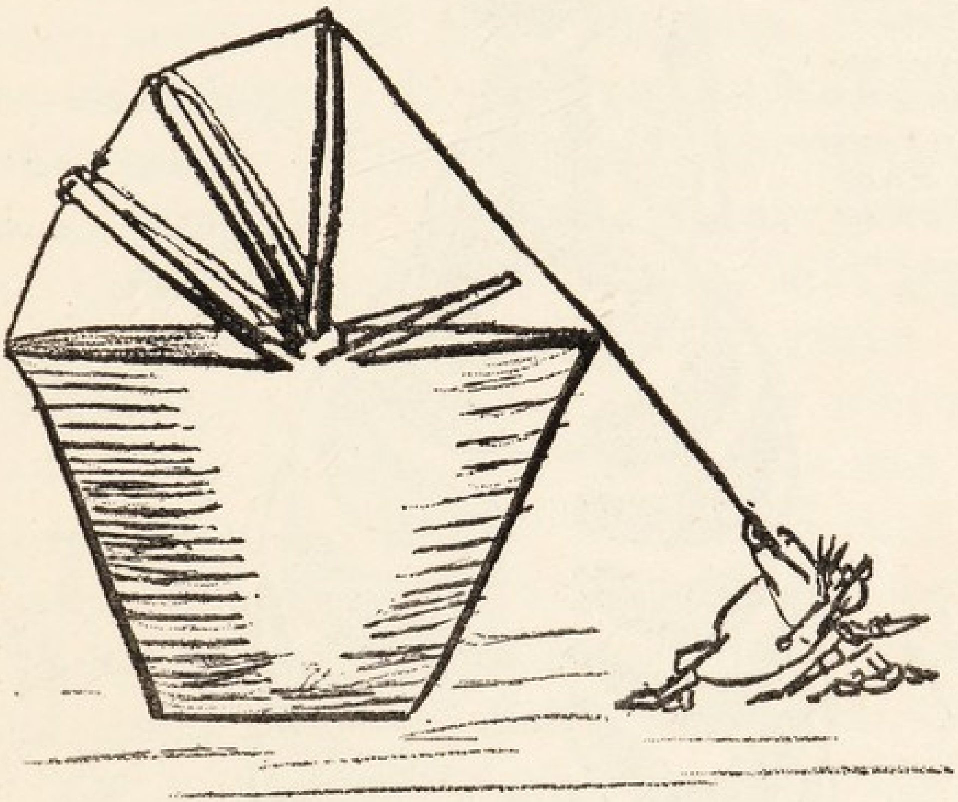
"Like an umbrella. Look at this picture. You see the ribs making the case, and the big elastic bag inside, and the muscles of the pump down below, which pull the bottom downward, and suck in the air; and the muscles above that pull the top up. Now look how like it is to an umbrella, if the ribs of the umbrella are closed in and the ferrule were the pipe for the air to come in by. (Picture 104.)

"You may say, also, that it is like a bucket-



104. " Look how like it is to an umbrella."

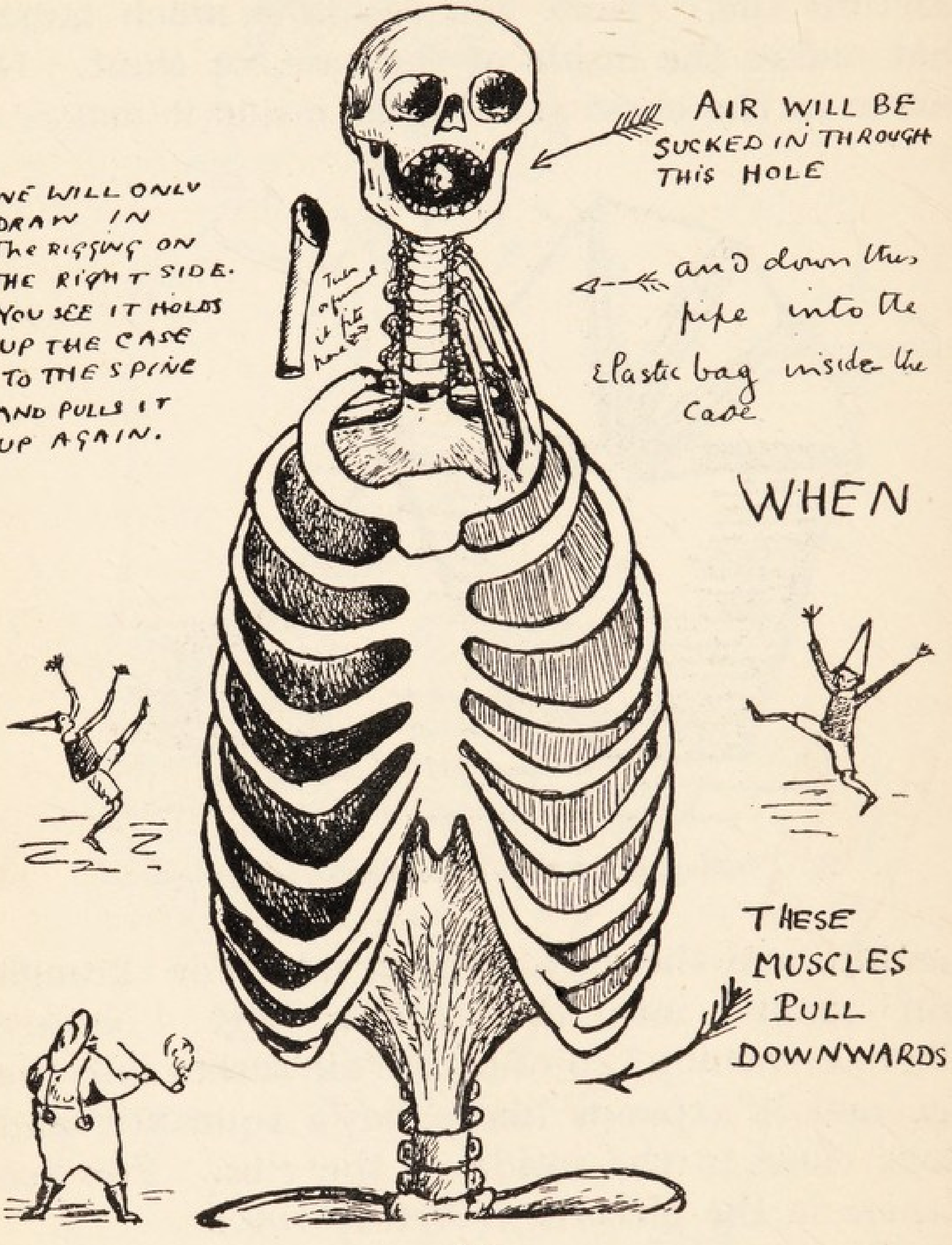
handle, because that is how the ribs come up. (Picture 105.) Here you see how much larger that makes the inside of the case, or chest. Of course as the chest gets bigger inside it makes a



105. Pulling up the handles encloses a larger space.

vacuum, and the only opening into it is through your mouth into the rubber bag. 'Nature abhors a vacuum,' so of course air rushes into the bag, and it expands like a boy's squeaker, and sticks close to the inside of the ribs. You see it there in the picture. (Picture 106.)

"Muscles are, of course, the things that pull the ribs up. You can see them in the side of the neck. I have left the others off to show better. It is just like the rigging of our boat, isn't it? You can call those muscles the chest


AIR WILL BE SUCKED IN THROUGH THIS HOLE
WE WILL ONLY DRAW IN The RIGGING ON THE RIGHT SIDE. YOU SEE IT HOLDS UP THE CASE TO THE SPINE AND PULLS IT UP AGAIN.
and down this pipe into the elastic bag inside the case
WHEN
THESE MUSCLES PULL DOWNWARDS

106.

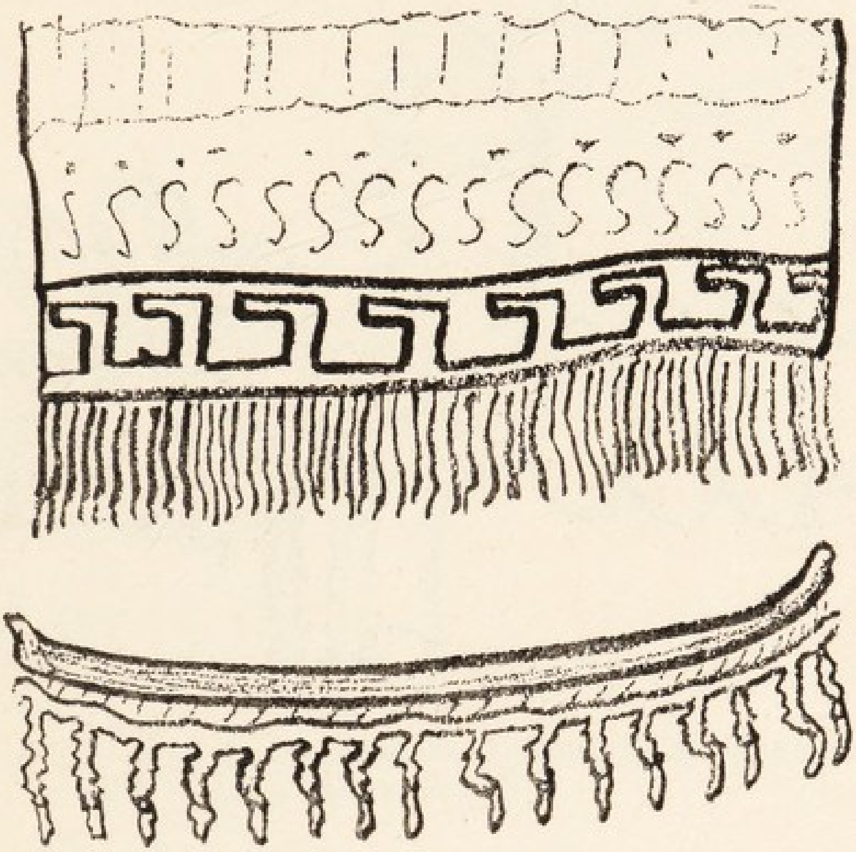
halyards, if you like. The bottom of the chest and top are closed over by flat muscles. That big fellow at the bottom, which is like the covering of an umbrella, is called the diaphragm. It is made of muscle, and it contracts about once in three seconds all your life—up, down; up, down; up, down. It never waits to be told by us, and never slumbers itself; it works away while we sleep just as when we are awake. It knows perfectly well what to do, and just goes on doing it from the cradle to the grave.

"Of course a whole lot of other muscles are needed. You have seen a boy's nose and mouth working when he is out of breath and wants more air. You have often felt your belly muscles helping by squeezing the bowels in and out, like a great cushion, which helps the pump to throw more air in and out quickly. Sometimes you have to grip hold of a bar with your hands to help pull your chest walls in and out still more freely and fully, especially when you are really 'pumped out'—after a race, for instance.

"Naturally all this has to be governed; and someone has to get the signals from the Reds as they come in. So I thought that you would like to know that there are two central offices, one in the top of the spine, one in the back and lower end of the brain. They are one on each side, and they are connected by wires to help each other out in emergencies. They have also kind of branch offices lower down, but these are only used for a minute or two if we happen to get a sudden knock-out. Then there is the 'wonderful wanderer' (*Vagus*), the same wire or nerve that is used in the pump regulator. It carries some lung wires also. These really are marvellous, because it is they that enable us while we run races to use twenty times as much oxygen as we should in just walking about. He shouts out, 'Stop!' 'Go!' and central works by his orders. He is a general benefactor, because, as you will see later, he also sends a few odd threads of wire or nerve to the stomach. That is one reason why, in a prize-fight, a home drive in the pit of the stomach knocks the wind out of the fighter. For the message flows over to the lung wires, and even the heart stops for a second."

"But, father, you haven't really told us how the blood got washed."

"Exactly as it got washed by oxygen in the water that rushed through the fish's gills. There, on the hoops, were endless fringes of long, tiny vessels. Here is a carpet fringe (Picture 107), and here the fringe of blood-vessels washing in the stream of water, that passes through a fish's gills and carries oxygen to wash the blood with. (Picture 107.) I say 'wash,' but it really is burning, just as gold is cleaned by being burned or refined. As we saw, fires burn only by having oxygen. It is the oxygen which burns up the dirt, and so makes everything clean. To do this the oxygen must be brought right to the object that is being burned, and so we must bring it right to the red corpuscles that want it first

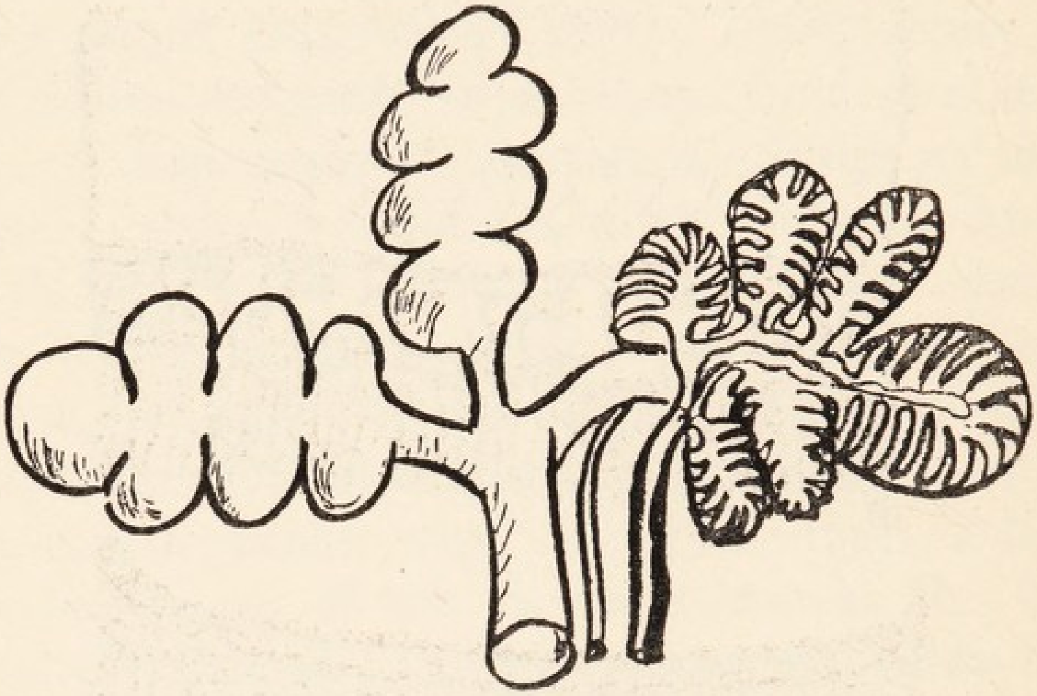


107. Air washes over the blood-pipes beneath the gills of fishes—they are like the fringe of a carpet.

to burn up the garbage which they have brought back from the body, and also some to carry back to the ends even of the fingers and toes, burning up other waste right on the spot, wherever it finds any.

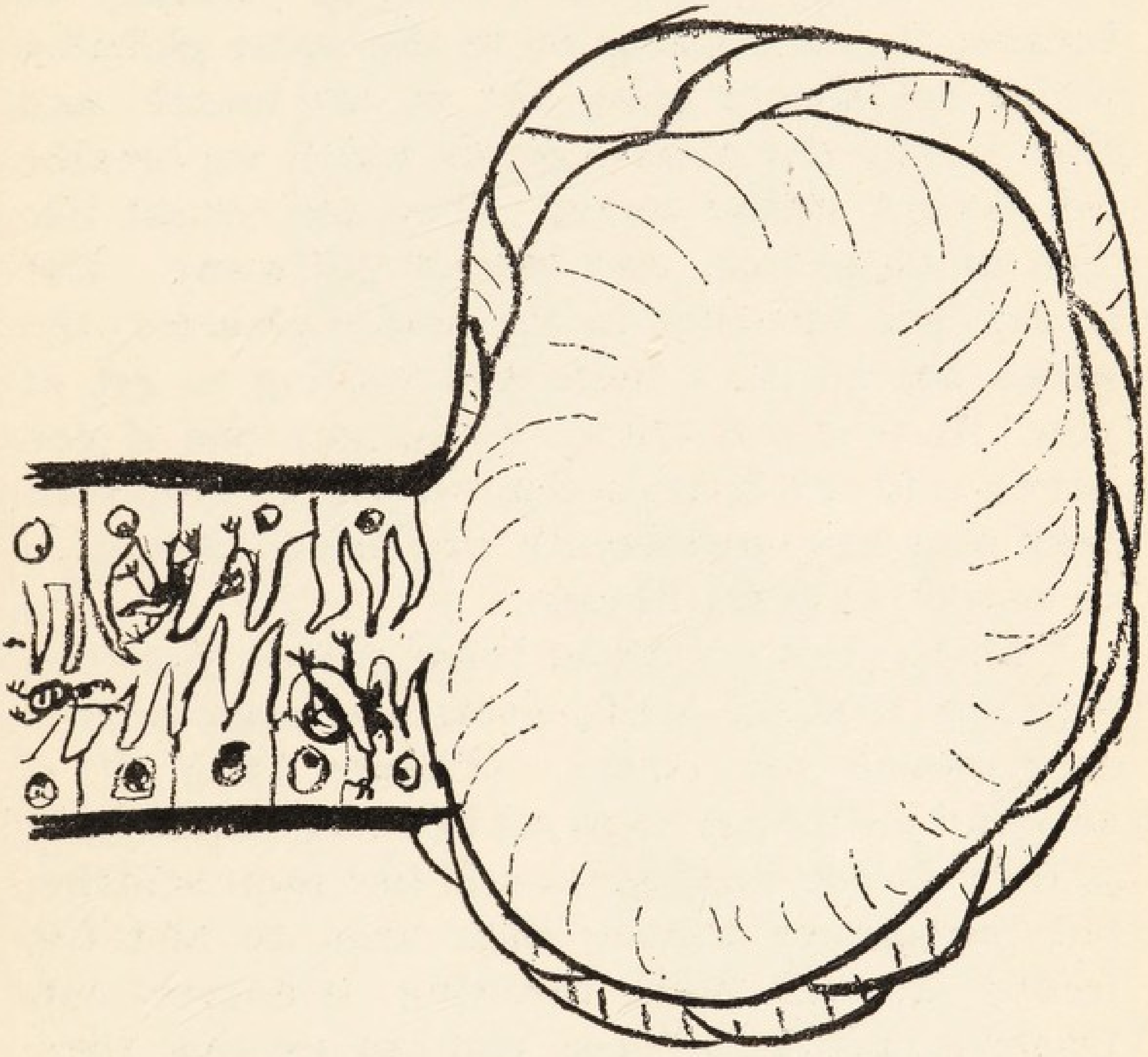
"We cannot very well have long fringes inside us. They would flop about and get hurt, because they must be so very fine. The solution of the problem is quite easy, however. (Picture 108.) We must fix the tiny vessels to the walls of the bag, and send the air round to them. Even

Mahomet had to go to the mountain when it could not come to him. The big bag is divided up just like a cauliflower. To give room for all



108. So in our lungs thousands of little pipes carry dirty blood round the air-cells.

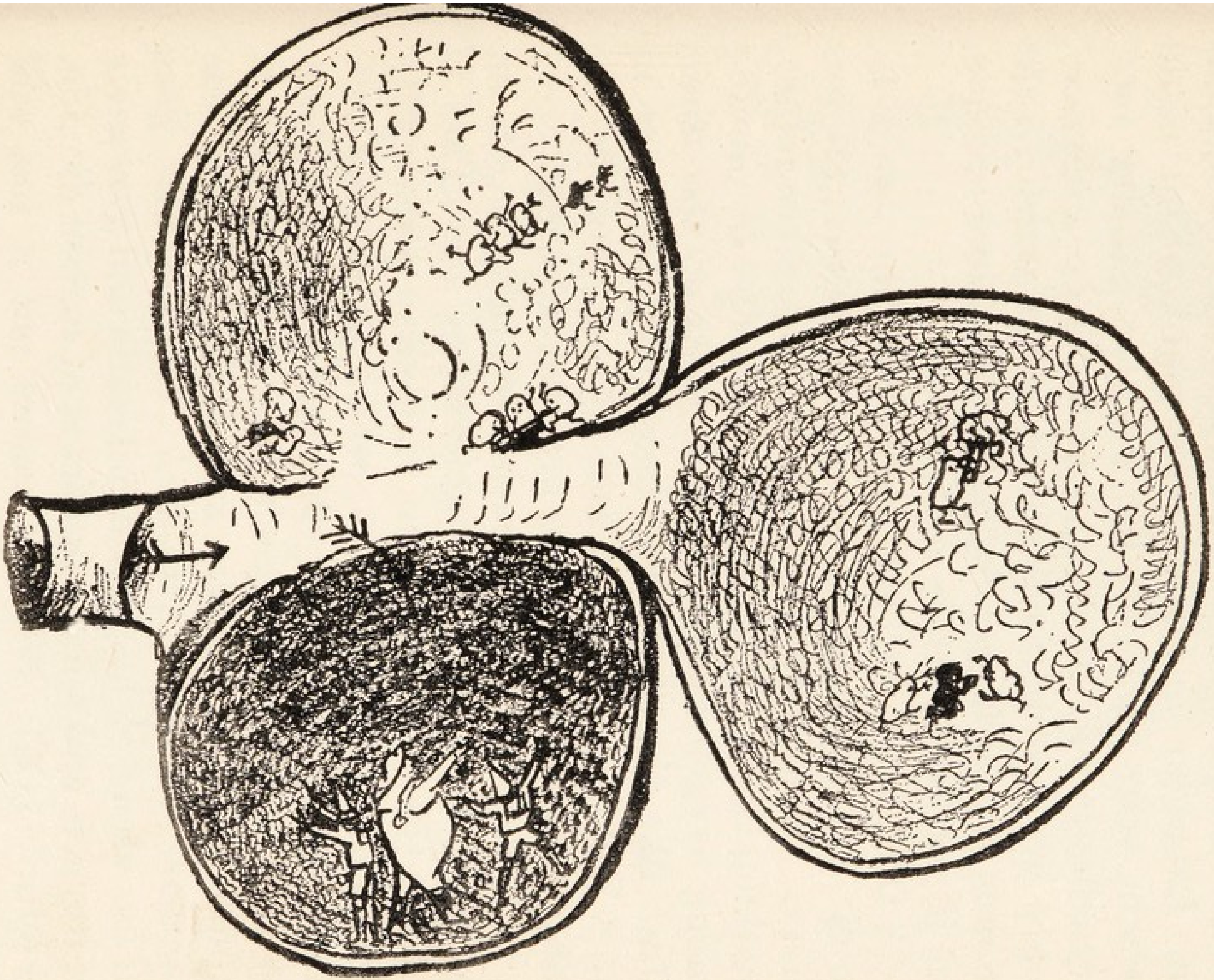
the Reds to get in the front row every single bit of it is hollow, and all the stems are hollow and end in rooms like this. There are about six million of these little rooms. Their sides are as thin as soap-bubbles. The surfaces of all of them spread out would be a hundred times as large as our whole outside skin. They are ever so neat—all the same size—all heated with pipes over the walls. They have to be kept absolutely clean. If dirt collects in them we die of consumption. Coal-miners, who work underground, breathe in lots of bits of coal, and some die; and the rooms of their lungs are found to be as black as coal. When you see a ray of sunshine coming through a closed window you can often make out how full the air is of dust. All that



109. The guardians of the air-cells arresting germs and throwing them out.

dust must be kept out of the inside rooms, so any number of guards are appointed to keep watch at all the entrances and hallways to the very threshold of the rooms (Picture 109), just as bees have guards at the doors of their hives who know every bee that goes in, and who throw out any strangers. These guards of ours catch all the dust and throw it back again, and often stick it all together as well. Sometimes we have to cough it up, there is such a lot of it. Usually we breathe it out, sticking on to the water globules, which are always going out in our breath, and that is why the disease germs which we breathe out do not spread more. They are caught like flies in tanglefoot, and cannot get away. But if any one breathes in the water globules, the germs are all alive there and waiting to get at you. It is a real crime to kiss any one if you have a cold or a fever, and never wise to keep your head near any one's breath who has consumption or any other germ disease.

"There are so many of these guards, that you may say that the walls, floor, and even ceilings are covered with them. (Picture 110.) It is an awful job for a germ to get by them, particularly as they do not stand stock-still like some sentries, but are always waving their arms to and fro, feeling around and throwing strangers out. Under a magnifying-glass you can see that there are little passages, which are always sweeping themselves out. When Mary sweeps she throws tea-leaves down for the dust to stick to. For the same reason our inside sweepers throw out a sticky stuff called mucin. They are just big cells. The walls and floors are all alive, and do their own cleaning. The rooms are also very pretty inside; the colour of the walls is always

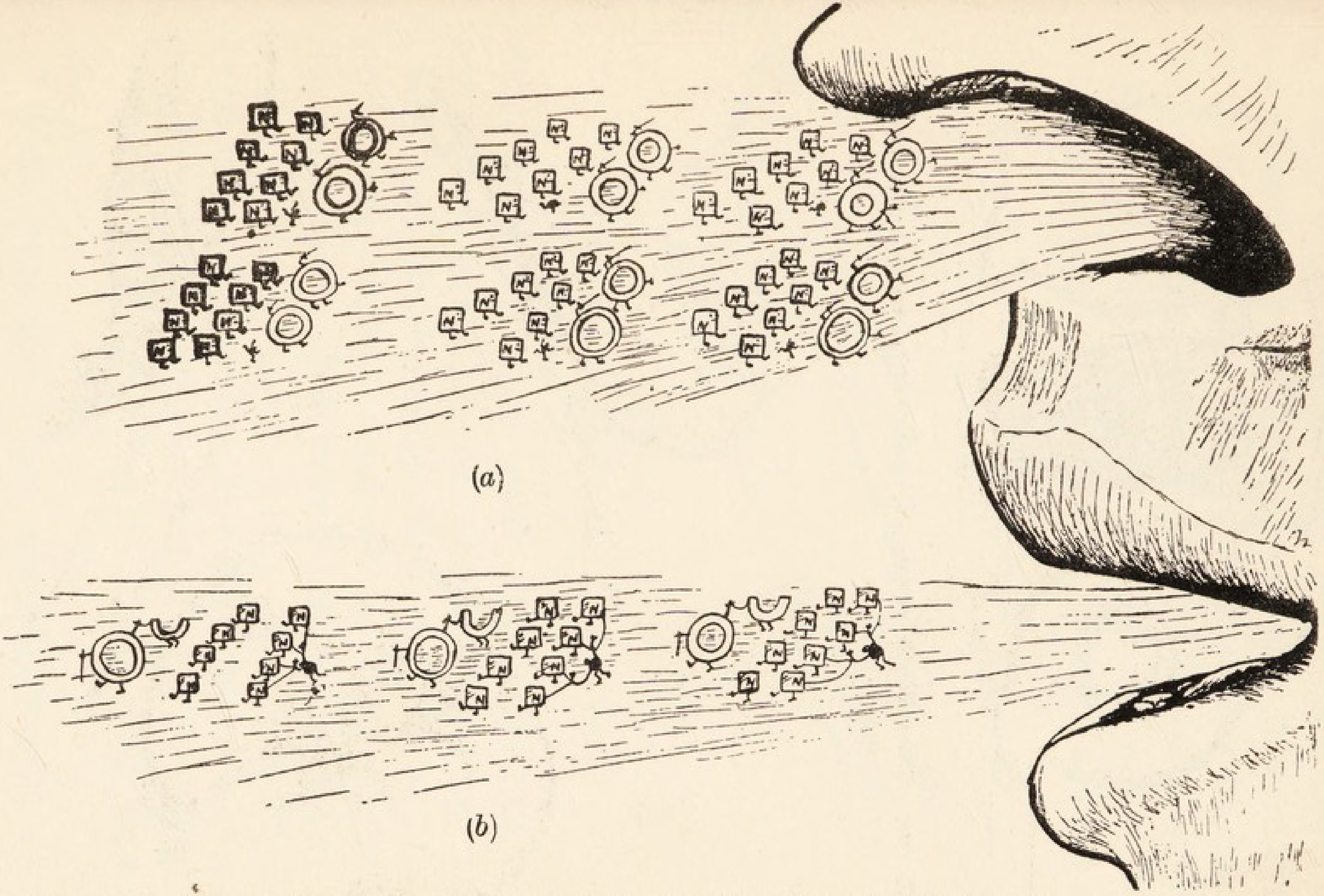


110. " Phagocytes " cleaning up tubercle germs and carbons in the great BEEHIVE called our LUNGS—like the tomb of King Tut.

changing blue and red, like the stage at the theatre in pantomime time. You would love such rooms in Labrador on a winter's night. You could warm your hands at the floor or walls or roof, whichever you liked, and go to sleep anywhere, only you would have to get accustomed to the rooms getting bigger or smaller every three seconds, as if you lived inside the bellows.

"Our lungs do not only look like beehives, they are beehives—busy every second all our lives. Moreover they are real furnace-rooms, making the heat possible for our bodies by sending along oxygen in the blood to burn up the ashes. Just like the fires that burned the garbage in the Valley of Hinnom and Tophet, outside the Gate of Jerusalem, these fires never go out.

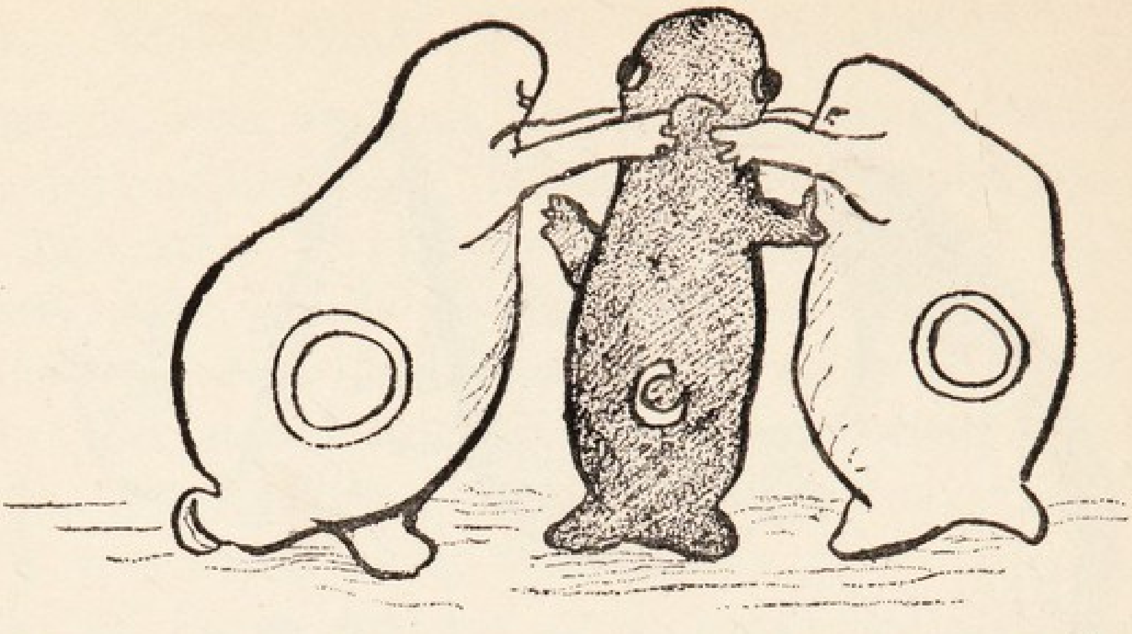
"Every time we breathe we take in on an average about half a tumblerful of air. That is called the 'tide.' There is always about fifty times as much air left in, which never goes out. You cannot get the ribs quite flat together. With a very deep breath you ought to take in about another tumbler and a half—that is the measure of your 'vitality.' The air that goes in has about eight parts of nitrogen and two parts of oxygen, and a mere suspicion of carbon dioxide. (Picture 111.) When it comes out it has still all the nitrogen and one-half the oxygen, and much more than double the carbon dioxide, but in chains. The air also is much wetter. That is the way that our bodies get rid of a lot



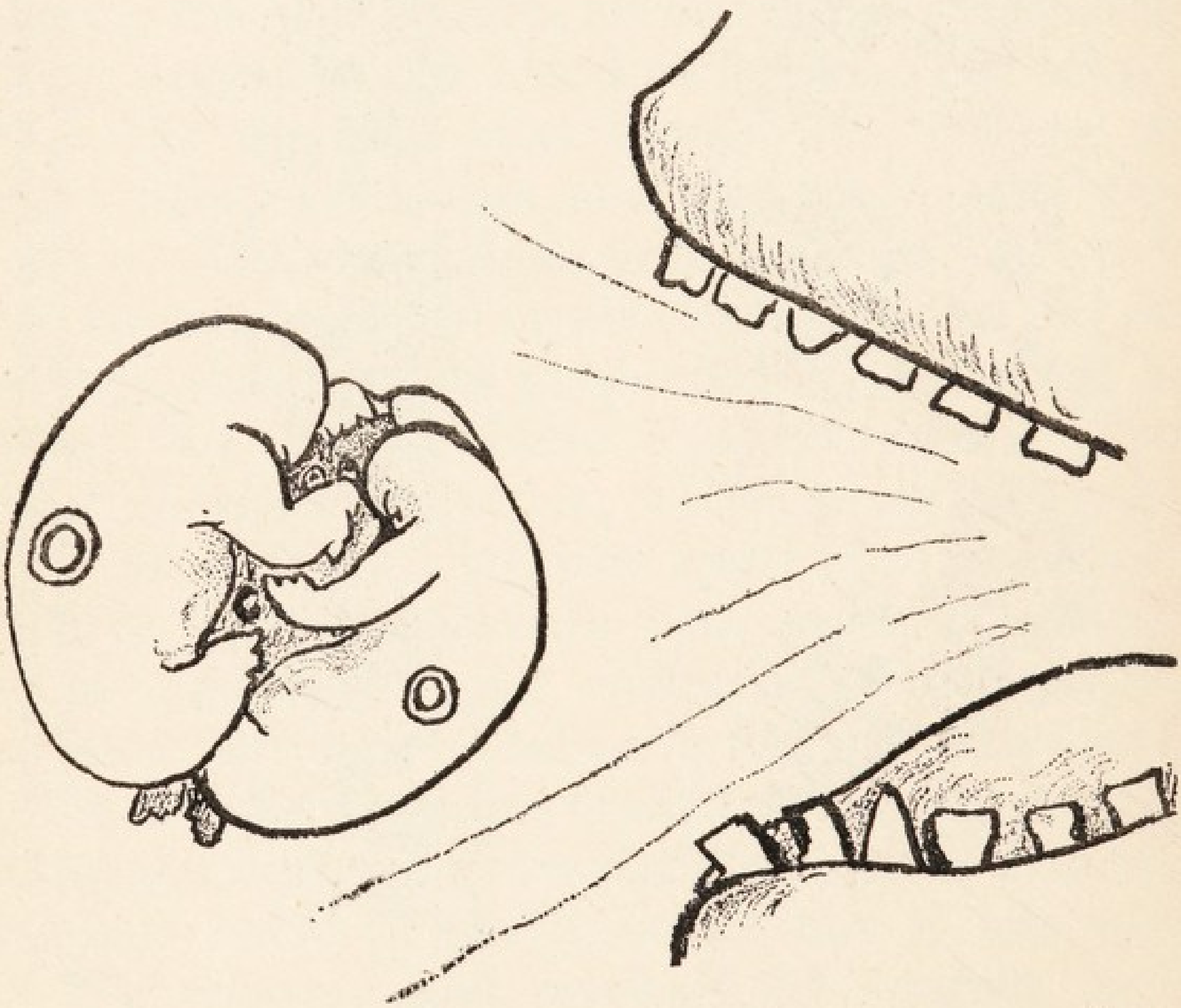
(*a*)

(*b*)

111. (*a*). Air entering nose. Nitrogen 8, oxygen 2, carbon dioxide a trace.
(*b*). Air leaving mouth. A simple mixture of nitrogen 8, oxygen $1\frac{1}{2}$, carbon dioxide $\frac{1}{2}$.



112 (*a*). Two White oxygen (O) policemen arrest a carbon (C).



112 (*b*). They then form one particle (CO_2) and are promptly "breathed out."

THIS IS CHEMISTRY.

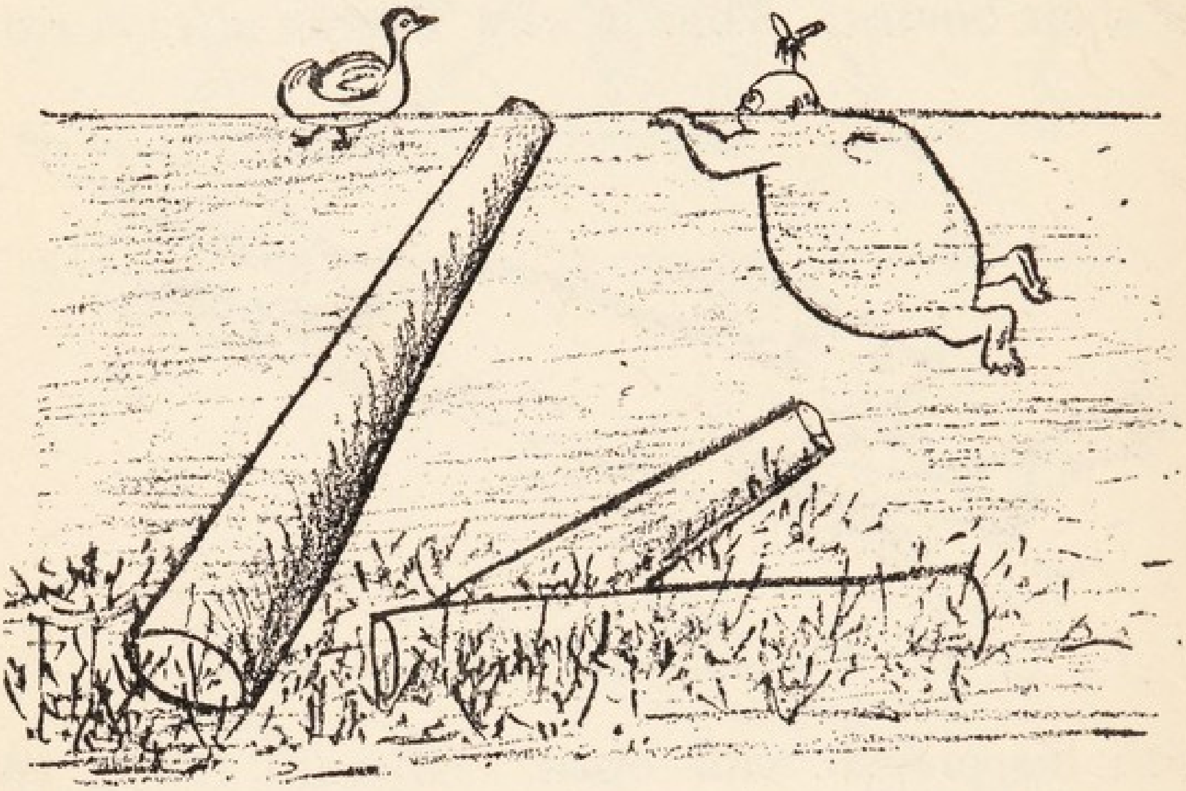
of water which we do not need. Of course we sweat some out. That is one reason it is necessary for us to do really hard work in order to become men. It cleans us up inside. Dogs do not have to sweat. They breathe out all the spare water of their bodies. That is why Towser always runs

113. They breathe out all the spare water.

with his mouth wide open. (Picture 113.) We pass some water in the urine, of course, but if it were not for the water that we pass out by our breath, we should soon be as water-logged as those old tree trunks which have lain out so long in the rain. (Picture 114.) That is why you get so sleepy in church; the air gets hot and moist, and still, so that you cannot get rid of water."

"Oh, father, *we* don't. It is you who get sleepy."

"Well, you see I am accustomed to such a lot of fresh air at sea. Doctor Grahame Bell made a man breathe into a glass bottle all day long, and found that enough water condensed in it to keep him from dying of thirst if he were adrift in a boat without drinking water. One of the worst mistakes mankind makes is this : ‘ Oh, you must not sit in a draught.’ Whereas really



114. We must get rid of water all the while or become water-logged.

our air must be kept moving. But that is one of those old chains which our forefathers forged for us before they knew any better. They made the chain that has kept our women dragging long skirts along the ground, sweeping up all the dangerous germs as they went along, and then bringing them into our houses. Women are only just beginning to get free, and now they are commencing to enjoy running around, and playing games, just like men do. Naturally they are stronger and better for it. Heaps of other chains, called 'conventions,' our forefathers made for us.

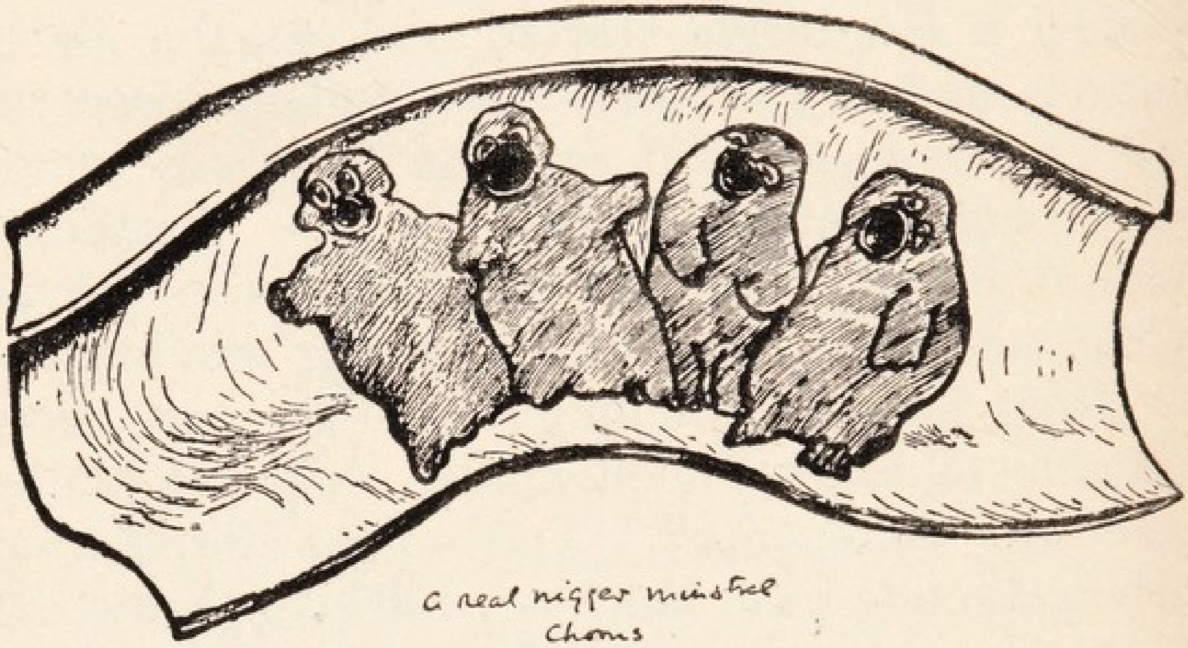
"Air to keep good has got to be like everything else, it has got to 'keep moving.' Once a lot of students were sealed up in a tight-glass room. Their cigarettes went out, the men wilted and dozed; a fan inside started and set the air in motion, and immediately the students were as well as ever again. It was the same air, but it was moving about. There is no dangerous amount of carbonic acid gas from people, even in big meetings. Just 'keep the air moving.'

"Here is another thing which is even more valuable to know. You realize that our bodies have lots of enemies. You might think that carbon dioxide gas, which we have to throw out of us, was our enemy. (Picture 112.) So he is. But our body is wise enough to make him into our friend, exactly as Frank used our old dirty ashes to make a good path to walk on, and used the garbage which, if left about, would poison us, to help the pigs to give us pork."

"How ever do they make him a friend?"

"Exactly like an alarm-clock. When we are asleep, if we have got our head under the pillow, like the little Princes in the Tower, we should turn blue and die. But long before that those ugly-looking carbon molecules would have rung up central in our brain office, and messages would have gone pouring in from every side, saying:

'We carbons are getting overcrowded. Something is wrong. Please breathe deeper and quicker.' (Picture 115.) And if the brain would not listen, they would stir up the muscles and the muscles would 'get busy' and send that



a real nigger minstrel chorus

115. Carbons become our friends and sound an alarm to central to wake up and send more oxygen.

pillow flying—so, really, the enemy carbons have become our best friends. Now that is how our breathing goes on while we sleep—tic, tic, tic, tic—the carbons keep on warning central every three seconds. That is what made you pant after holding your breath. It was those villainous-looking little carbons in the red corpuscles warning central, and that is the feeling you noticed, and that is the voice of the Reds—a real negro-minstrel chorus.

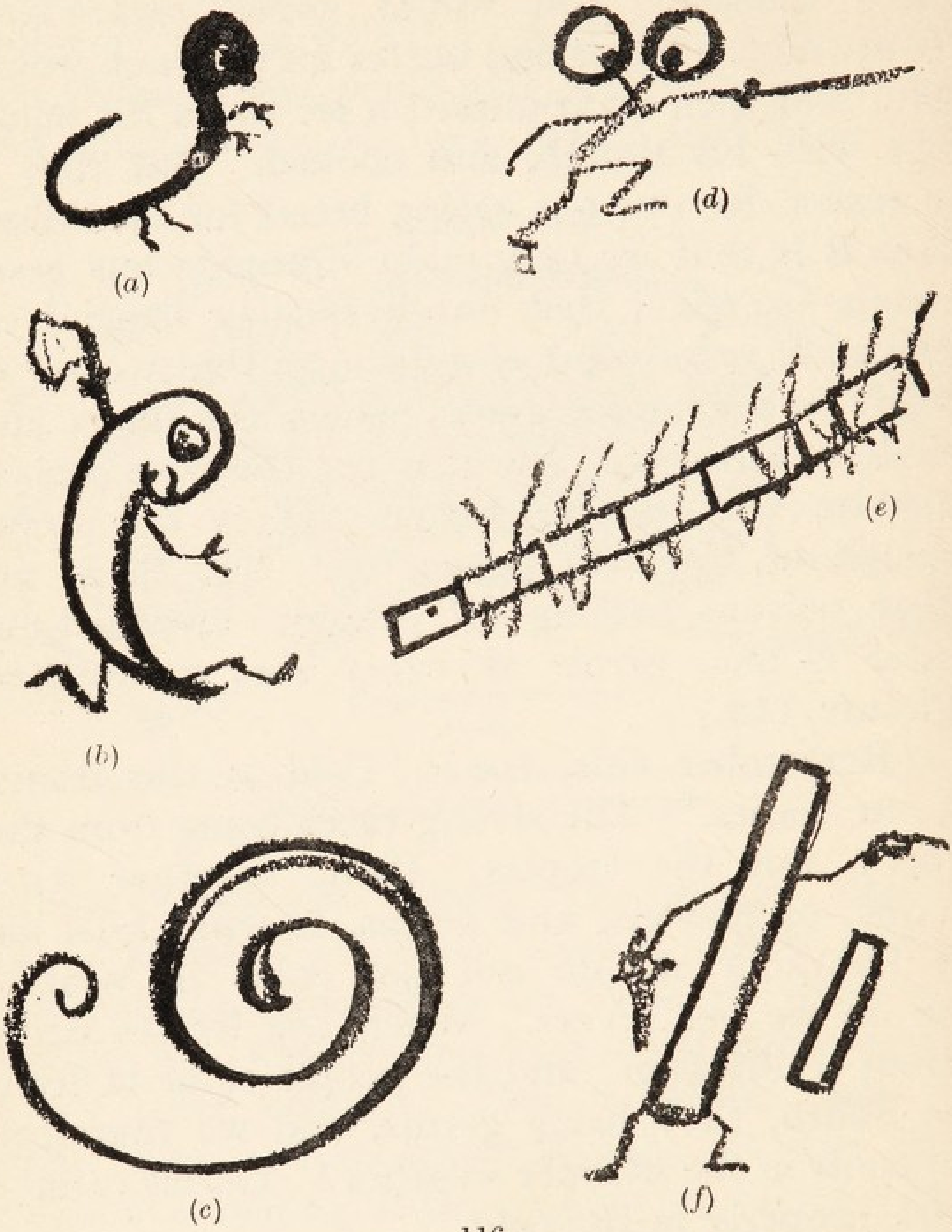
" So it is with draughts. Too much of anything may be an enemy and destroy us. At an asylum where I was once a doctor one of the poor lunatics killed himself. You would never guess how. He ate all the bread and butter his stomach would hold, and then he crammed a lot down his windpipe with his thumb, and choked. But that is no reason for our not eating bread for breakfast. Thus it is that we may make draughts our good friends—so good that our lives may depend on them. It is for want of a draught that we get so sleepy in a crowded room, where the doors and windows are shut. No, it is not the poor carbon dioxides that are to blame. There are never enough of them to poison us. But there are other poisons coming off people; breathed-out water is one, germs of every sort are others. (Picture 116.)

"Remember this, too: 'Cold is the friend of our bodies.' The strong races come from the North, not the tropics. Heat, together with toxins, or poisons, and germs, is what kills us. In Labrador we do not get colds in winter, nor do we get fevers. When the letters come 'from civilization' and the people come in from the South, they bring germs, and we therefore get colds in the warmer weather! Germs cannot work properly in the cold.

"Here is a thing that the world needs to believe more than all I have told you. It, and it only, can save the world from wars and murders.

"Why, what is that, father?"

"It is the one and only way to get rid of our



116.

(*a*). Cholera Bacillus.
(*b*). Typhoid.
(*e*). Spirillum.
(*d*). Diphtheria.
(*e*). Streptococcus.
(*f*). Tuberculosis.

enemies. There is an old story that to cure the cat that ate too many cockroaches, you must give it a dose of chopped-up beetle; or to cure a silly boy who is smoking cigarettes, give him a 'whacking big' cigar. What did we do to save our soldiers from dying of typhoid in the war? We vaccinated them. How did the world get rid of smallpox, which once killed millions of people? Vaccinated every one. How do we prevent colds nowadays? We vaccinate against them. Yes, we make the germs cure themselves. You only get rid of your enemies by making them your friends. And you can only do that by loving your enemies, that is one of the great 'laws of life.'"

CHAPTER XIII

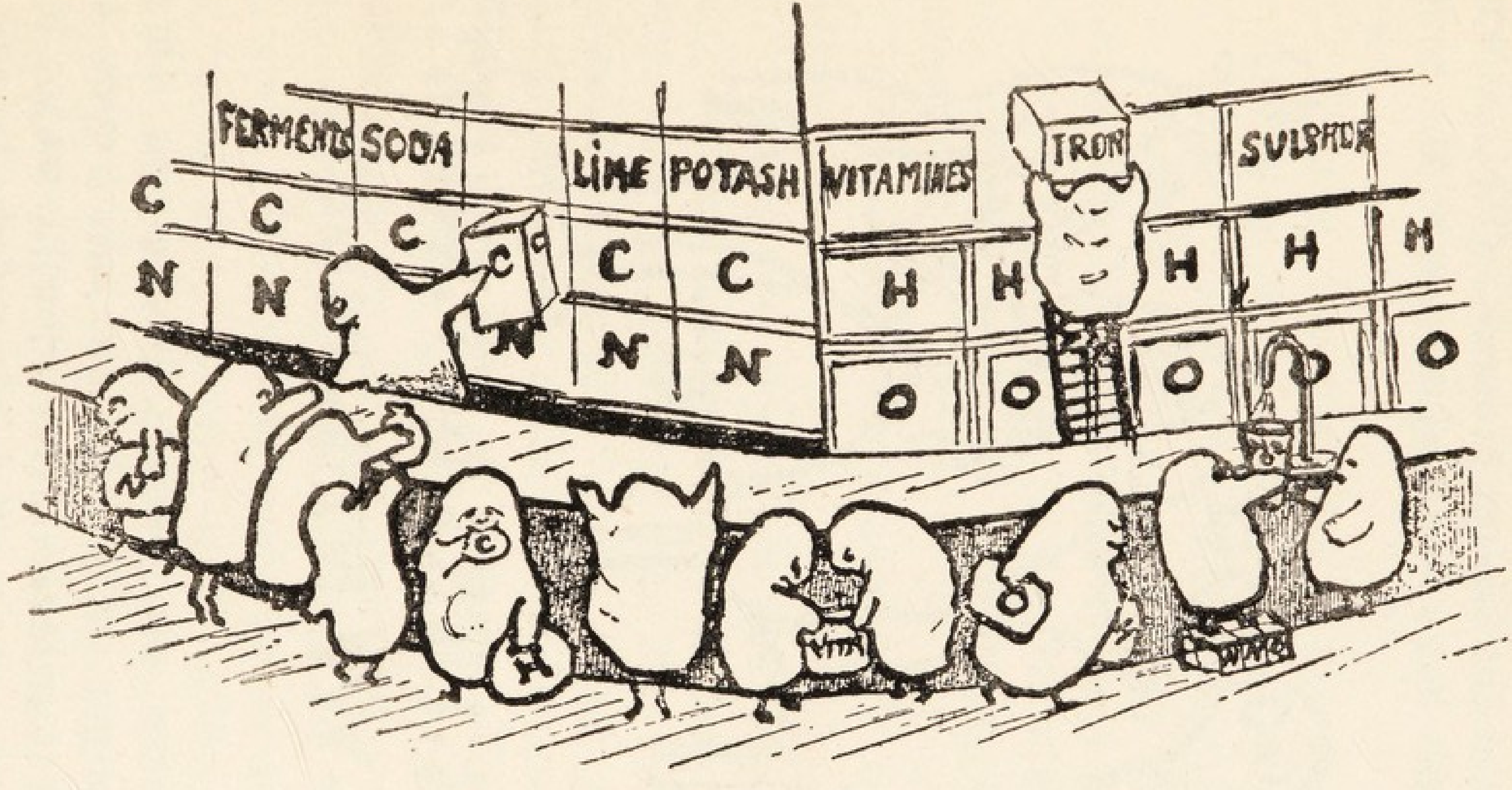
THE BUILDING DEPARTMENT

"WHAT are our bodies built of, father, and who does the building?"

"They are built of clever little cells, which are doing the work of building and repairing all our life long, like electric 'ever-readies.' They are of every kind, and can do everything. Thus, thousands and thousands of them live all along the side of the long red lane that we put their building material into, and they do the rest.

"It is they that ship the supplies to every part of the body, where other builders pick out exactly what they need, whether it is for a nose or a hair, or a tooth or a toe-nail. The supplies are carried everywhere by the blood, which is their 'American Express Company.' So they really do go by canal, as we saw the other day.

"Of course the supplies department may not put into their post great huge packages, like a beef-steak, or a whole onion. Their business is to break everything up and send it along in the tiniest parcels. Then each cell in the body everywhere knows exactly what it needs, and helps itself as the express passes by. (Picture 117.)



117. The supply department can only give cells very simple things.

It is just like hungry guests at a table when the butler passes the dishes around. (Picture 118.)

"The cells have five main wires to the central

EACH. PICKS. OUT. WHAT. HE-WANTS. MOST.

118.

office. These are called the senses. One is for our tongue, others for our nose, eyes, ears, and touch machines. Our mouths water if we smell or see or even think of good food; and the central office then directs our motors through our hands and eyes to put into our mouths building material that can be used, and at the same time tells our eyes and nose to watch that it is not any old piece of iron or garbage or mud.

"All the tiny particles in our food are stuck together by energy. Isn't that a strange kind of cement? But it is really the same that keeps our old world buzzing around the sun, and glues the stars in their places. Our food is like charges of dynamite, which tiny detonators inside us can force to shoot off its energy, all ready for us to use."

"Then don't we make our own strength, father?"

"Oh, no, our bodies do not create one bit of new matter, any more than an automobile does. We must put gasolene into the tank all ready made, or the car will not go. Our bodies are the same. They are mere machines, and we get out of them only what we put in. Fortunately for the world there is one thing in it that can create more dynamite out of waste, especially out of the waste of our bodies after we have thrown it away. You would never guess what it is. It is called the 'green-o'-leaf' (Chlorophyll), and is the substance that makes any leaf green. That is why I take my hat off to all green plants. (Picture 119.) The world could not last any time without chlorophyll. That breaks up waste, and catches the energy of the sunshine, and sticks the particles together in new blocks, and then hands them to us as new, ready-made food cartridges. If it is a potato, or flour, or corn, or porridge cartridge, we call it starch. The storehouse cells keep these with the sugars. They are all labelled 'carbohydrates,' because there is carbon and water in them. Hudor means water, which is made out of oxygen and hydrogen. If

119.

the plant stores have been eaten by animals and turned into beef or eggs, then they contain another old friend, nitrogen, and have to be labelled 'proteids.' If we eat the plant stores that we know as olive-oil or nuts, or fats from plants like beans, or from bacon, then they are practically all carbon and hydrogen, and so are labelled 'hydrocarbons.' Building cells use carbohydrate cartridges for power or energy, while they use proteid cartridges for framework material, and hydrocarbons as fuel, for heat and wrapping and greasing. It is easier for the cells not to have too many kinds to choose from.

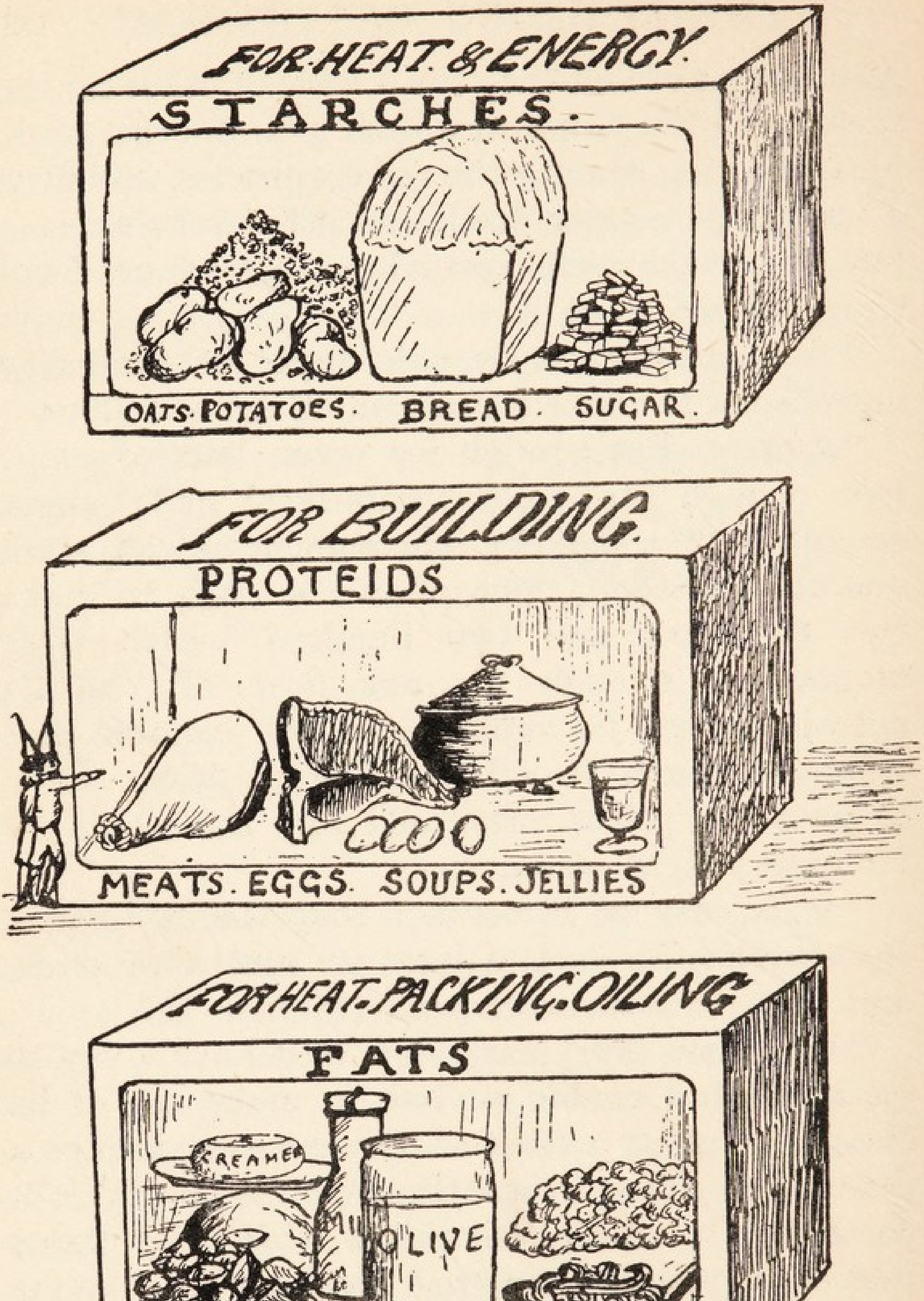
As a matter of fact they use a little of other things, such as a little sulphur, a little phosphorus, chalk for the bones, iron for the red corpuscles, and even a very little copper, lead, and other substances—but all in such small quantities that we need not worry about them now.

"A chemist recently said that the necessary ingredients to make a man out of are as follows:

"*Items:* Fat enough for seven bars of soap; iron enough for one medium-sized nail; sugar enough to fill a shaker; lime enough to whitewash one chicken-coop; phosphorus enough to make two thousand and two hundred match tips; magnesium enough for one dose of 'salts'; potash enough to explode one toy cannon, and sulphur enough to rid one dog of fleas. Even at post-war prices you could buy the whole lot for ninety-eight cents.

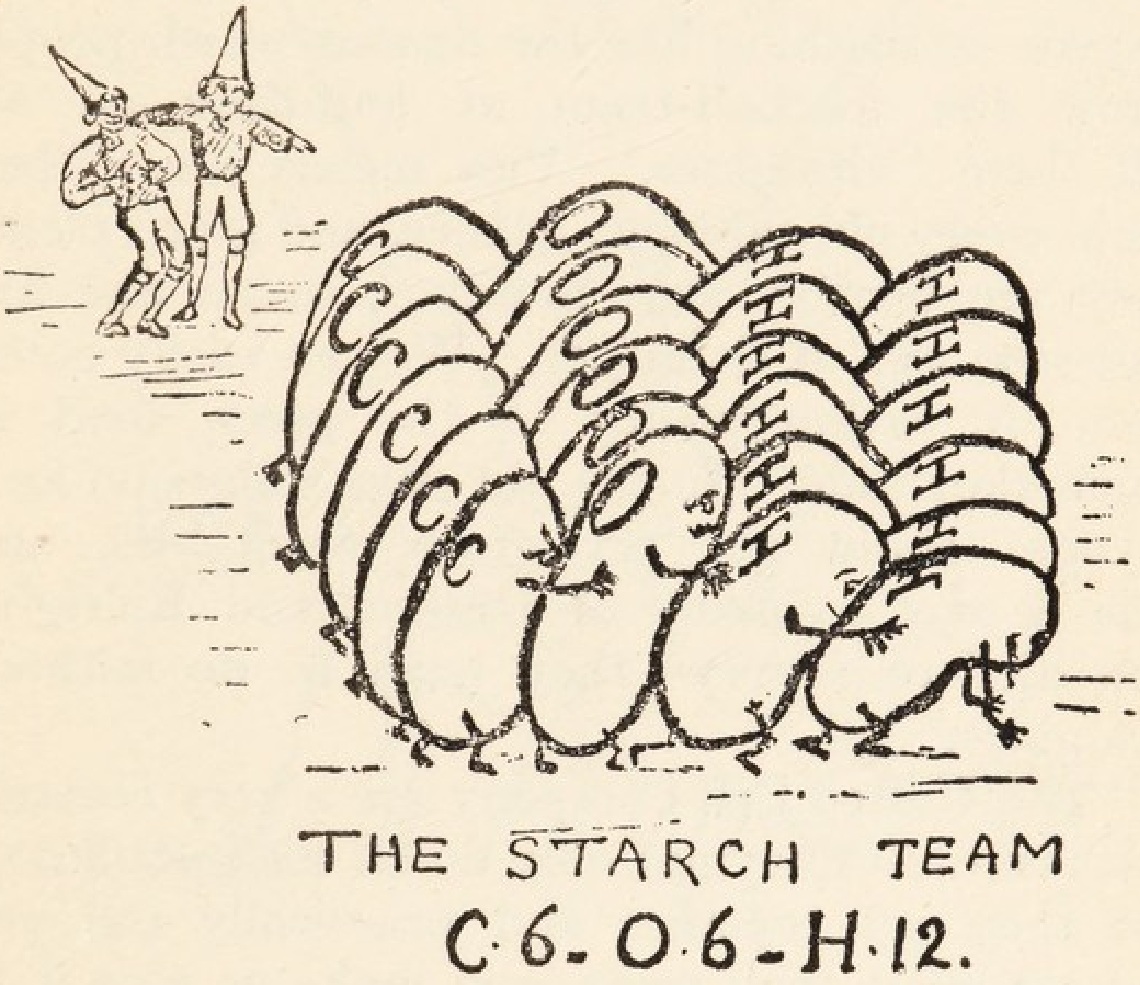
"It is easy to remember that the body uses the starches for fuel to burn up meats, proteids, and fats, or hydrocarbons. (Picture 120.)

"Of course every cartridge must have a cap to set it off and enable anyone to make use of its energies, just as a stick of dynamite must have a detonator. That is exactly what the supply cells do, they set off the cartridges which the plants make; or you can say that the cells are playing the great game of life, and the plants keep sending down the things to play with. Now we will label each player. H does not stand for Harvard, but for hydrogen; O not for Oxford, but for


FOR HEAT & ENERGY.
STARCHES.
OATS. POTATOES. BREAD. SUGAR.
FOR BUILDING.
PROTEIDS
MEATS. EGGS. SOUPS. JELLIES
FOR HEAT. PACKING. OILING
FATS
CREAMERY
MILK
OLIVE
NUTS. BUTTER. OILS. MILK. FAT. BACON

120.

oxygen; C not for Columbia, but for carbon; N not for Newfoundland but for nitrogen. The plants arrange these players into regular teams. We start them marching down the red lane,



121.

and the cells set them free to play. The cells know exactly how to use each team, because they know how many there are of each kind of players in each group. Thus the Starch Team has 6 C's, 6 O's, and 12 H's. That is the team, as you now know, which gives us energy the quickest. You will learn about the other teams some day. Each has the same kind of players. (Picture 121.)

"There are a few special things which the supply cells must have to do their work. These things they cannot manufacture; and for them we have got to go back once more to our friends the plants. These things are to put life into the players—something like the lemons which people throw the football-team at half-time—so we call them 'vitamines.' Vita means life. They are in every old cabbage, lettuce, and green plant. They are terribly shy, however, so no one has ever seen one of them yet. We can easily catch them by eating plenty of the green food in which they hide. In the old days sailors on long voyages could not get green vegetables, and that is why so many of Drake's and Raleigh's men died of scurvy—they tried to do without vitamines.

"The United Cell Company are a very remarkable crowd. They not only do all the upbuilding, but they get together and practically tell you and me what they want, and make us give it to them. When they shout out, we know what they want, and we call it 'liking a thing.' As a rule they call up central about three times a day, for they have a wonderful habit of looking ahead, and they want to have supplies just where they can get them when they need them. Thus we call their shout for H and O being thirsty, because two H's and one O make water. By the way, do you know that about three-fourths of our whole body is water? Sometimes they call out:

122. A chorus of "CHOCOLATES."

'Sugar, please.' Are your cells calling anything now?"

"Yes, chocolates," came in chorus, as the eyes of the class fell on a box of Huyler's on the bench. (Picture 122.)

"But how are you to grow big and strong on chocolates?"

"Oh, the cells will take care of that," was the answer.

"Well, you must remember that the cells won't stand for bad treatment. What happened to Billy when he ate too much candy?"

"Oh, he was sick."

"Yes, that's right. If you overburden them, the cells throw it out again at once, back through your mouth, if they can. But it hurts them all the same, and at last they get so that they cannot throw anything out; that is, they get poisoned. The label that we have for poisons is 'toxins.' If you swallow too many poisons you become intoxicated. That is why Uncle Sam will not allow drinks with toxins, or poisons, in them in the United States any more.

"Too much fat is a sort of poison. Never get fat. Never be greedy. It hurts you most of all. Greed makes cruelty, and ill health, and even world wars."

CHAPTER XIV

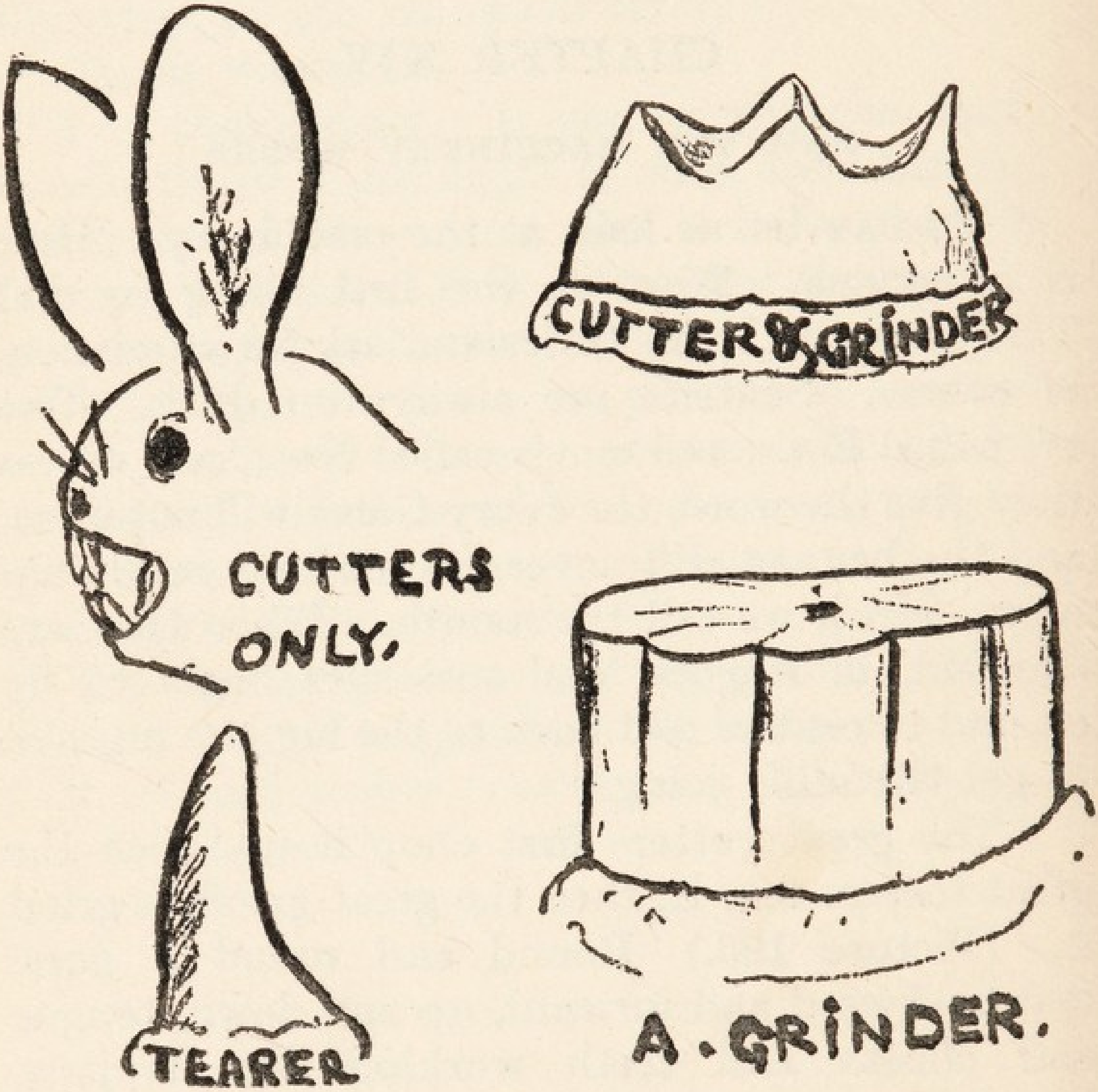
HOW THE MACHINERY WORKS

"To-day let us look at the machinery. Here is a banana. What is the first thing to do? Take it to the Ivory Gates and ask for admission, of course. Sentries are always on duty. Two are called Eyes, and one is called Nose, and unless they give the word, the Ivory Gates will not open, and the banana will never get into the receiving-room, which we call the mouth. When they are satisfied, in it goes, and messages begin to fly around to central and back to the big jaw muscles to get the mills going.

"The great cutters first chop it up, then the great tearers tear it, then the great grinders grind it. (Picture 123.) Round and round it goes, and backward and forward, up and down, tongue and cheeks and teeth working like Trojans. Meanwhile, six fountains pour out water on it and soften it all up, and chemicals in the water dissolve the tough places, just as Mary uses ammonia to dissolve out stains, or a ferment called yeast to explode the starch cartridges and make the bread rise.

"Always give these helpers time to work.

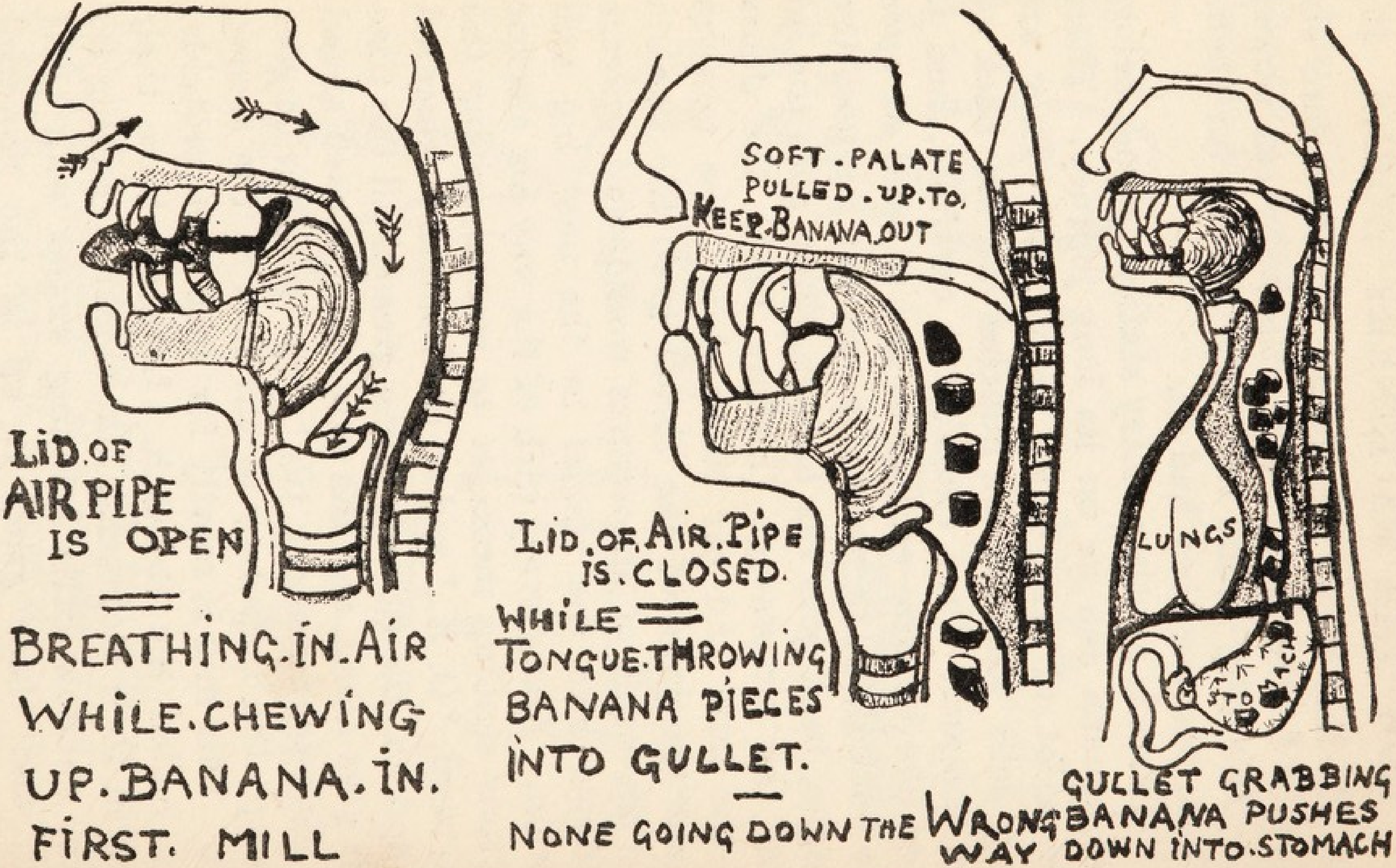
Chew well, and you will avoid many troubles. The most important chemical in the mouth is the one that turns starches into sugars, so that



123.

they can be absorbed through the walls of the red lane into the blood. It is called ptyalin. Little babies do not have it because they should only get milk for food. In Labrador, when the mother cannot feed her baby on milk because she cannot get it, she chews the bread herself before she gives it to the baby. Then the baby can absorb it. This they found out very cleverly for themselves, because they had to.

"There is another sentry station to pass before the banana can go on its long journey. There are a lot of cells called taste-buds. They are long cells standing in bunches at the back of the tongue. They examine it carefully, and if they like it, wire central to say so, and at once the back door, or palate, is opened; up goes the tongue, back goes the banana, down goes the lid over the air-passage (Picture 124); the doors to the nose and ear tubes close; the muscles round the jaws of the throat grab the banana like the arms of an octopus would, and squeeze it down into the tunnel to the next big mill station. Along every inch of the way are electric buttons sending messages to central, giving the password, 'O. K.,' and so the banana is squeezed on and on, the runway being greased all the time as it goes along, and the gate being opened ahead by a special message; till 'plop'—and in he goes through the trap-door in the roof of the second mill. This mill is mostly for meats or proteids. It is called the stomach. Lobsters have their teeth in their stomachs, and chickens, having no teeth, swallow little grinding stones with their food, and these grind it up in the powerful machine called the gizzard, which is an extra mill just before their stomach; while cows throw


LID OF
AIR PIPE
IS OPEN
BREATHING.IN.AIR
WHILE.CHEWING
UP.BANANA.IN.
FIRST. MILL
SOFT.PALATE
PULLED.UP.TO.
KEEP.BANANA.OUT
LID.OF.AIR.PIPE
IS.CLOSED.
WHILE
TONGUE.THROWING
BANANA PIECES
INTO GULLET.
NONE GOING DOWN THE WRONG WAY
LUNGS
STOMACH
GULLET GRABBING
BANANA PUSHES
DOWN INTO.STOMACH

124.

it up again into their mouths and grind it up over and over again. We call that chewing the cud.

"In our stomachs, however, we use only chemicals—acids and ferments—manufactured in thousands of little shops. Round and round, to and fro, goes the mill. Muscles, arranged lengthwise aud crosswise, churn and squeeze and roll the banana. It takes a lot of work to do it well."

"What is an acid, father?"

"Well, here is a dirty old copper coin. I am going to drop it into the acid in this saucer. Watch it. It is getting quite bright. An acid is an eater-up of most things."

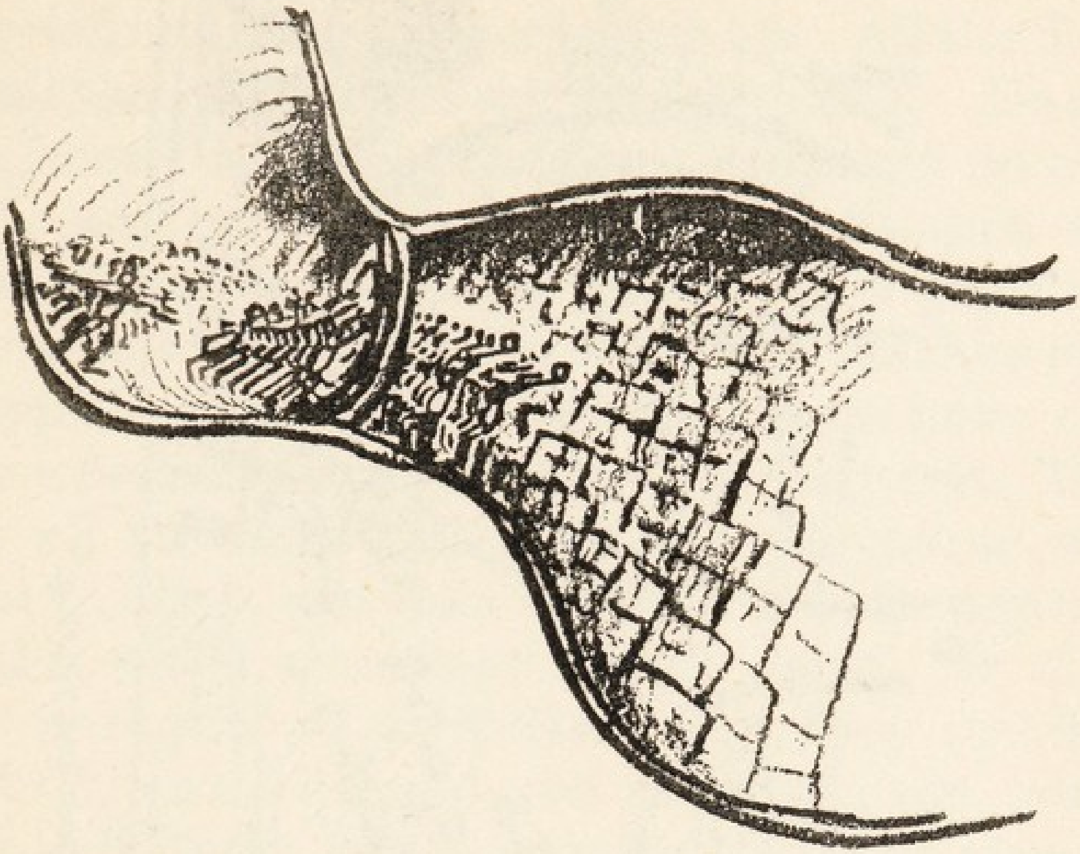
"And how does a ferment work?"

"Do you remember the tins of milk that blew up? Well, that is how ferments work. They blow things up. Yeast is a ferment. It blows up the dough and makes light bread, full of gas. When we fill the mill too full it blows up tight, and as the heart and lungs rest right on the top of it we feel our heart beating hard, and also get short of breath. A pint and a half is all that the mill is supposed to hold, but nearly every one puts too much in it at a time.

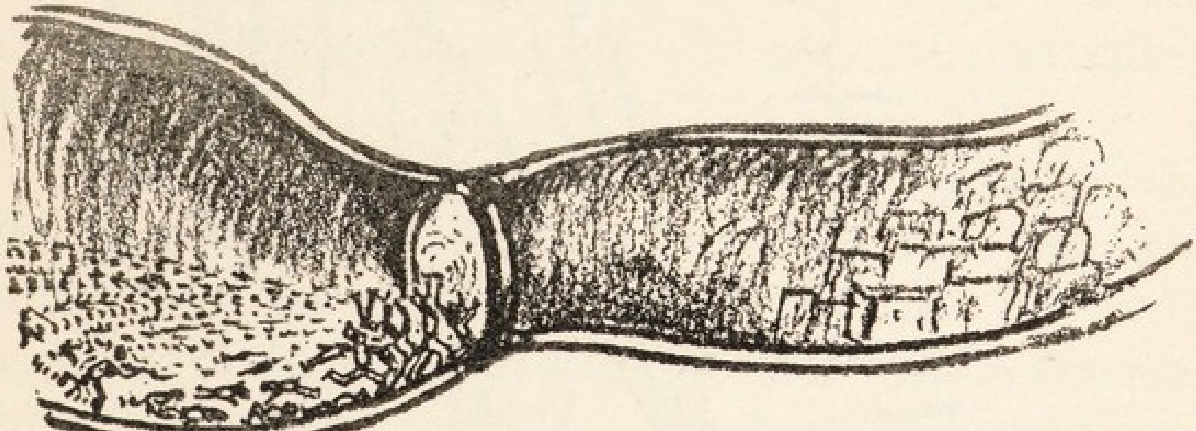
"At the other end of this mill house, another very clever cell guard is kept. Among the guards are certain ones that can tell when it is better to open the door and let some of the ready-made material be passed on. So they warn the other guards who form a strong heavy ring right round the fare-way entrance, and they open the gate, and then the first order of building material goes through at once with a rush. No large piece can get through. The guards see to that. But anyhow very soon there is a 'snap,' the gate is shut almost immediately and the mill goes on again grinding, rolling, and getting more stuff ready.

"The trouble is this. Inside the mill, as I told you, the guards have to be Red guards, or acids, while outside the door, they have to be Blue guards, or alkalies. Of course that keeps both sides very keen. When the acids get strong enough inside, they force the Blue keepers to open the door. Then some Reds get through and attack the Blues. (Picture 125.) That stirs up the Blues, so that they instantly make central shut the door and call up allies, who swallow up all the Reds that have got through. That is why only a little building material can ever get through at one time—why it takes four or five hours for one meal to pass out, which some people take only ten minutes to put in. This, however, is a mighty good thing, or the work would never be properly done. Half-finished stuff would get through, and there would be awful trouble inside us, just as if someone were to drop a monkey-wrench in the machinery of the motor-car.

"The only rest the poor stomach cells ever get



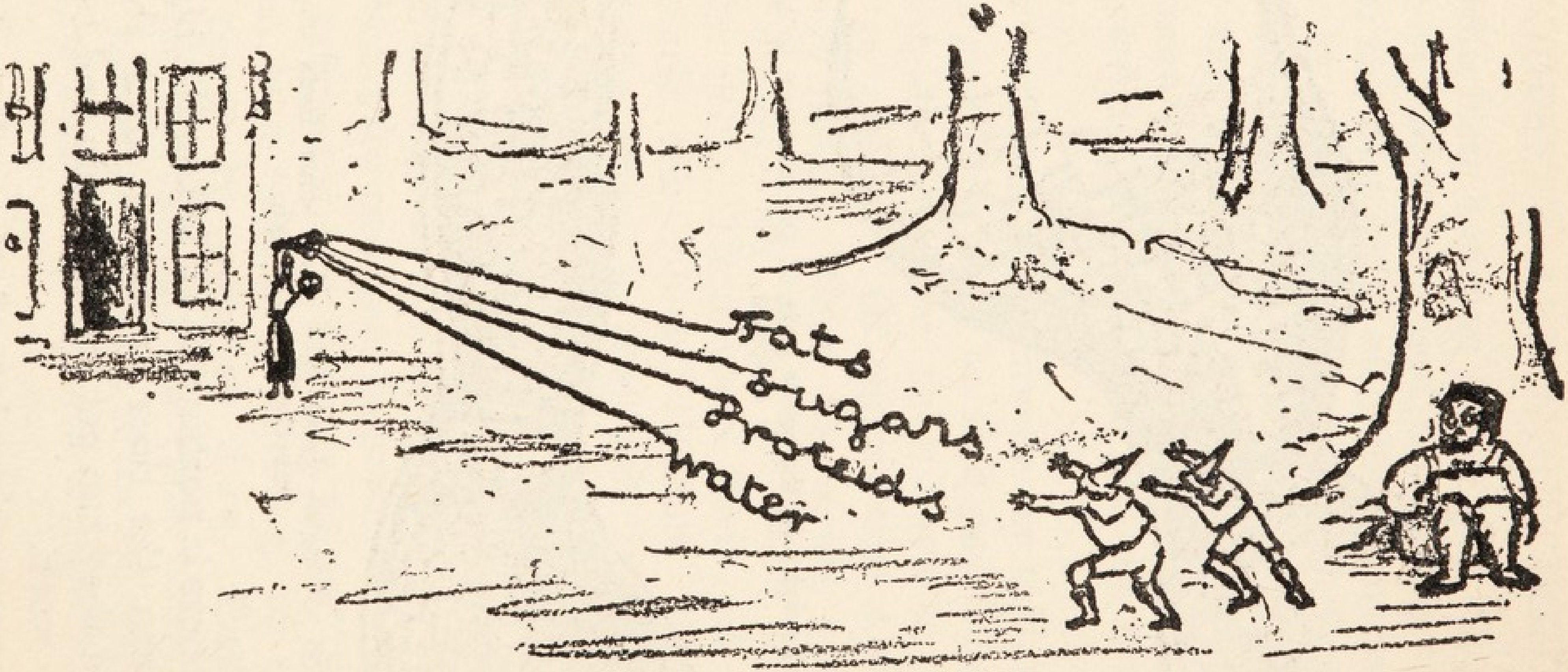
125. (*a*). The fight at the great gate of the stomach to let supplies through.



125 (*b*). End of fight—great gate shut, some Reds trapped—but supplies gone through.

is when there is nothing at all left in the big store-mill. Then the door is closed until the next meal, and they can get strong again and be ready for more work.

"In the meantime, lots of other cells inside have



126. " There is our dinner-bell ringing."

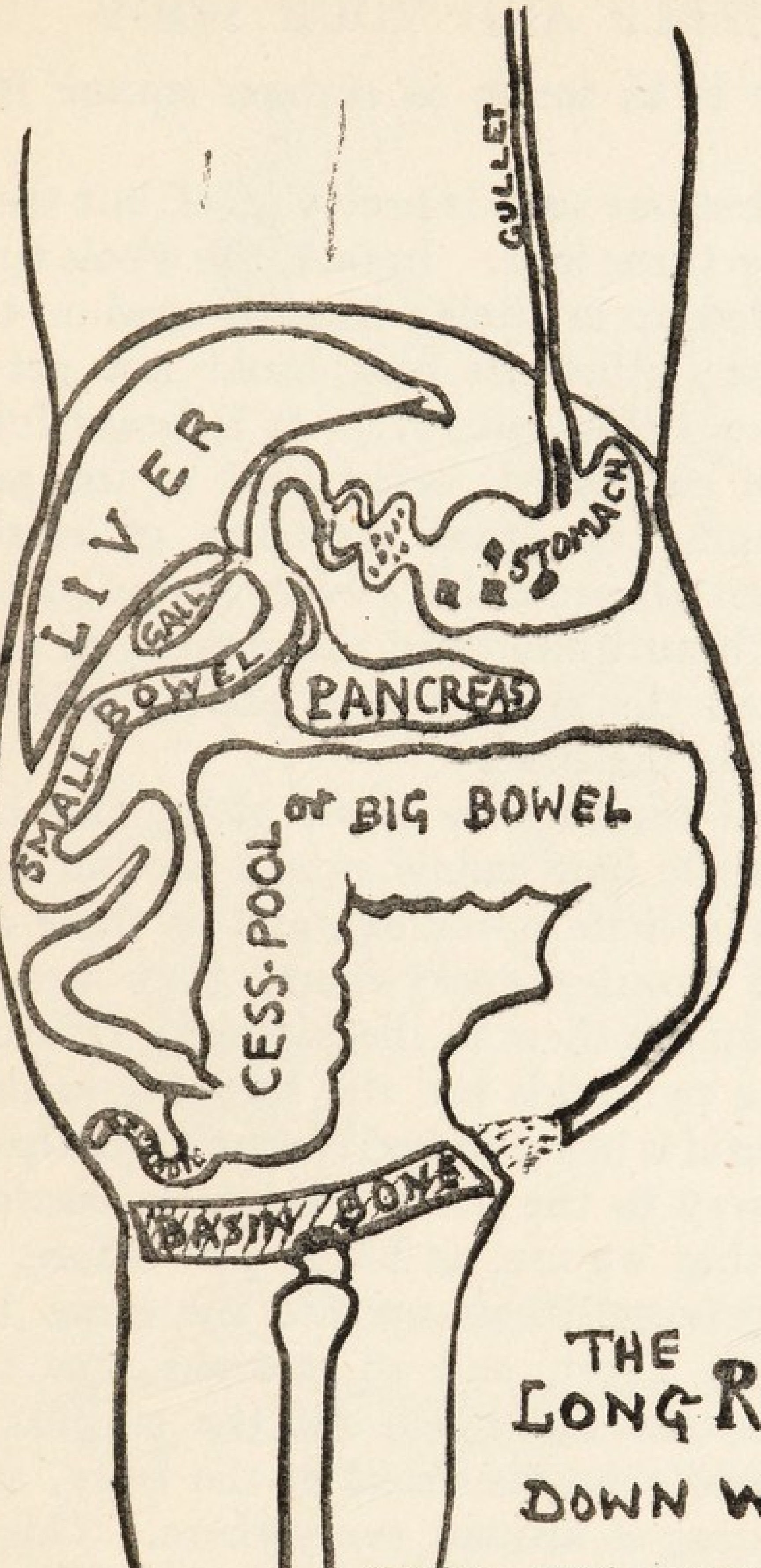
hurried and cleaned everything up. All the doors of all the small shops are closed up also. No acid is allowed out, and everything is washed up carefully and carried away by other cells, just as I showed you in the lungs. Then other guards oil the whole of the inside, while the machinery is stopped. That is why this mill must have rest. Some foolish people will not give it any rest. They are all the time filling up the storehouse with food or drink, and then they are awfully surprised if the whole machinery breaks down, or if all the workmen go on strike. This they certainly will do, and will send you an ultimatum, which you call 'pain in the stomach.' Then there is nothing for it but a good rest and a good washing out. That is the best thing to have done, almost always. It is quite simple and generally satisfies them.

"When at last the store is all ready again, other watch cells at once warn central; and central rings the hunger bell for the next meal. What it says is: 'More raw material, please. More starch, more fats, more proteids. We must have carbon, hydrogen, oxygen, nitrogen.' Why, listen! There is our dinner-bell ringing. (Picture 126.) To-morrow we will follow the banana through the gate. It is only 'gone on before.'"

CHAPTER XV

DEPARTMENT OF PUBLIC HEALTH

"LET us suppose to-day that we are travelling along after our old friend the banana, while the machinery is working. Suppose that we have just heard 'open sesame,' have dashed through the guards at the gate, and have heard the lock snap behind us. We now find ourselves in a marvellous place. It looks like the Subway, though it is really only about twenty feet long, and ends in another closely guarded gate. It is lined, just like the rooms in the heating department, with endless fringes, and it has all along it things that look like hurdles, or obstacles in a race. They really are put there to prevent our friend the banana, and all other building material, from hustling along so quickly that the workmen in the various departments along the sides of the tube cannot get enough time to get in their work on it as it passes. Also, of course, the surface being wavy like the inside of the lung or the central office, there is a great deal more frontage on the main street, and so there can be many more shops which will have their front doors on the



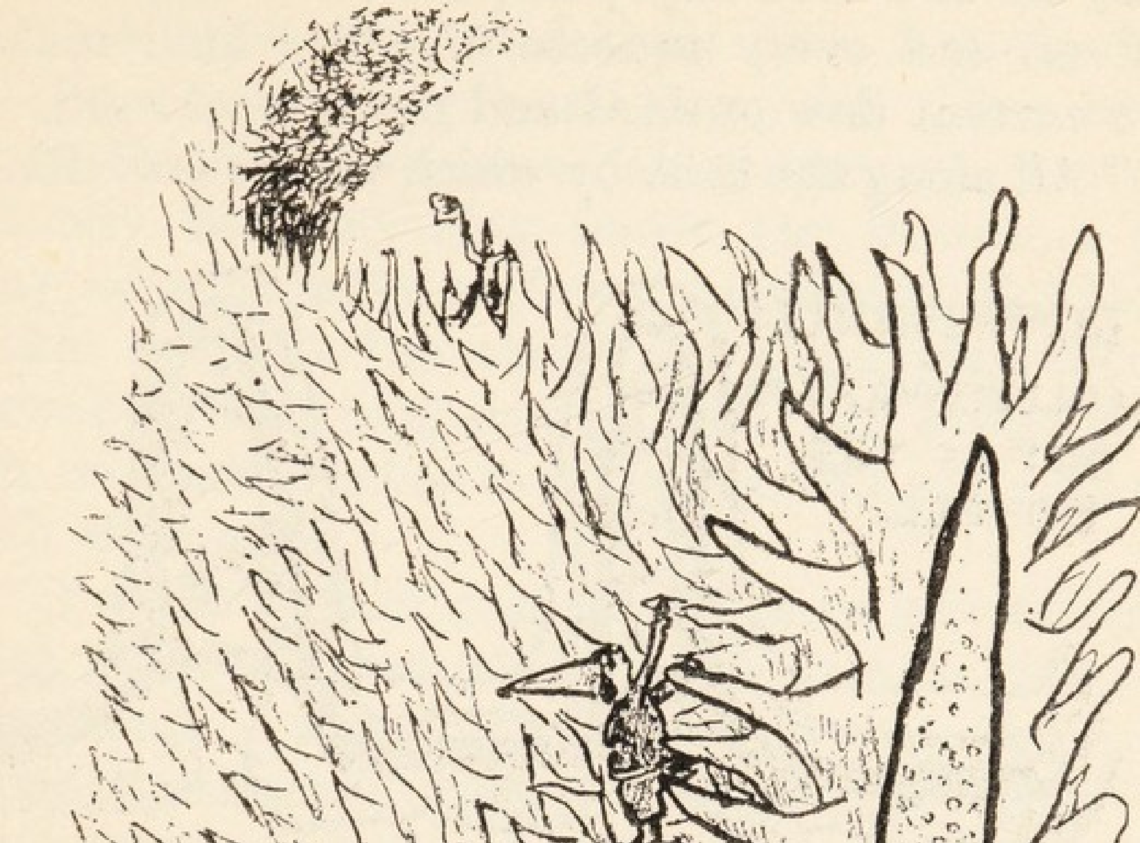
THE LONG RED. LANE DOWN WHICH. OUR FOOD. TRAVELS.

127.

road. There is as much as sixteen square feet of surface.

"Just at first our tube is pretty level, but there are very sharp turns in it. In fact, the whole tube has to be rolled up in circles, like the road on the mountain side; otherwise you could not get it into the space. (Picture 127.) It is beautifully arranged and supported, being held to the perpendicular spine by stout stretches of elastic ties; and also all around it, everywhere on the outside, is a beautifully oiled membrane, so that however much the spine jumps about, nothing gets hurt inside the tube.

"Big blood-vessels run down along the ties and end in little hair canals wound around tens of thousands of little pyramids, and as these are all over the hurdles everywhere, they are in millions. You see them in the picture. (Picture 128.) In the pyramids are the shipping canals, and the material is being passed through into them, and swept away to the place where it is wanted. All the fats that we use, as I told you before, go directly by private canals up into the great big veins near the heart, and so straight into the blood. If we eat too much fat the surplus is stored up, mostly on the front of the belly, and we have to drag it around everywhere. This is a picture of the inside of the pyramids (Picture 129), and the preceding one is the inside of the lymph canals, or ducts. (Picture 128.) You see

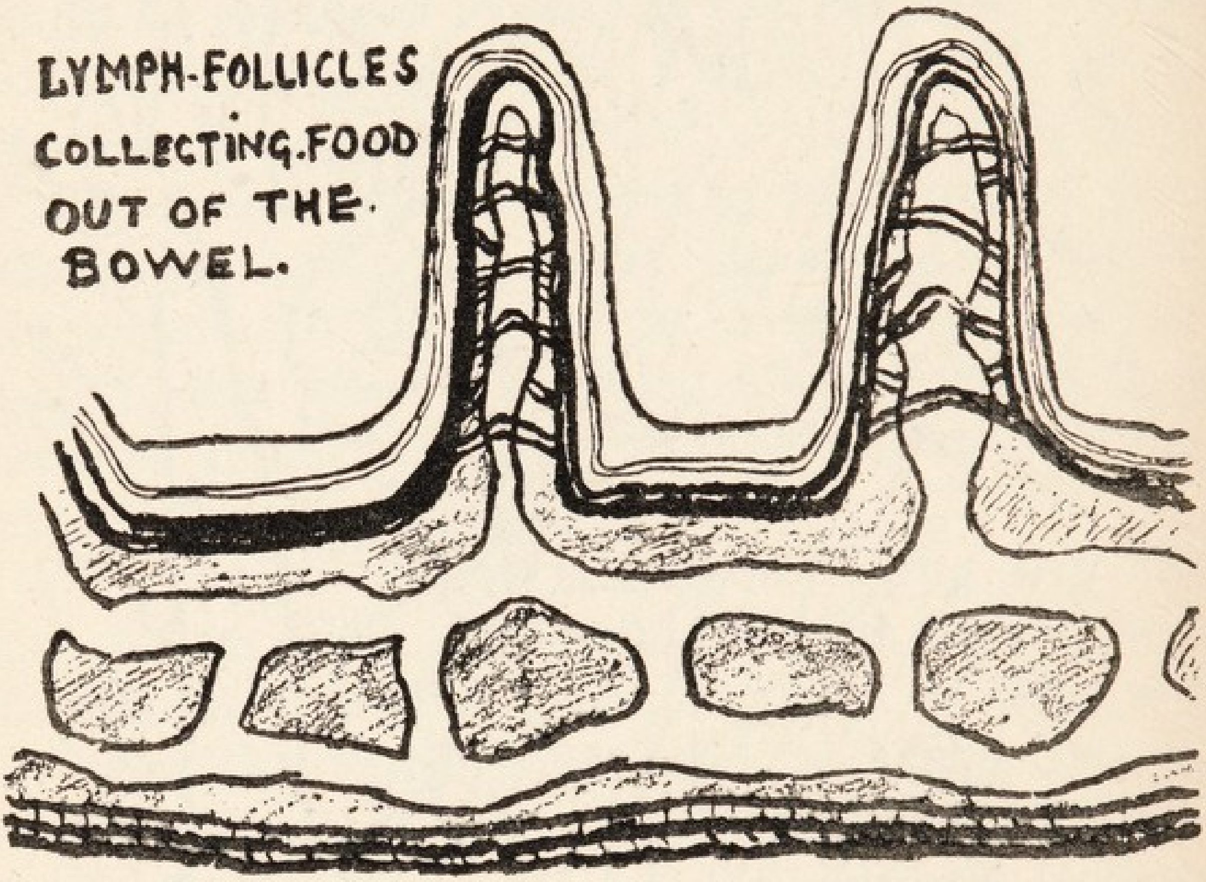


A-CIRCLE- OF. LYMPH. FOLLICLES. ROUND. INSIDE. OF SMALL. BOWEL. SUCKING. OUT. FOOD.

128.

they do not need any pump because they are all valves, and every squeeze of every kind makes the current flow onward and never backward.

"All along the tube by which we are travelling,



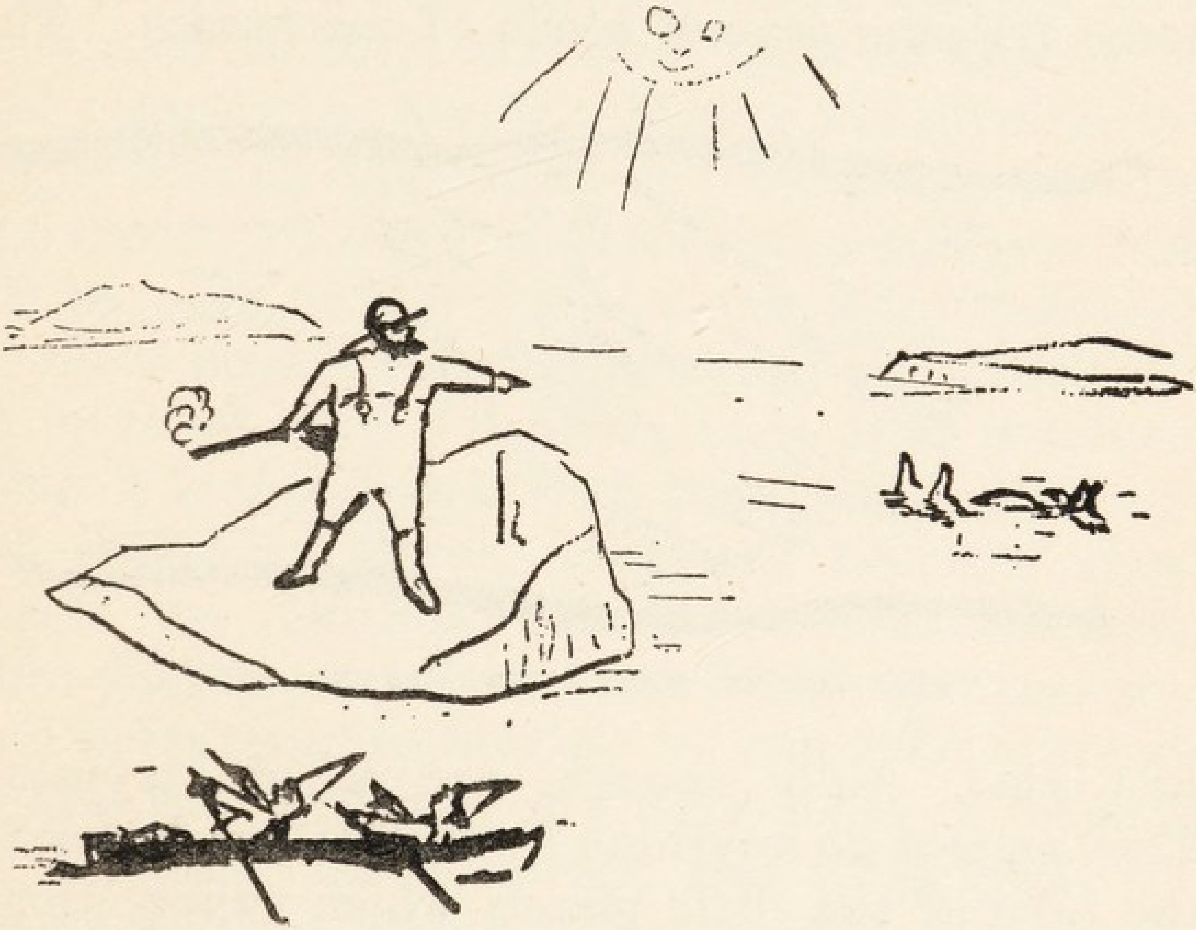
129. The inside of a pyramid.

and which, by the way, people call 'the small intestine,' we shall notice millions of little factories. They look like little holes. The little doors open everywhere—some single ones, some in groups. Out of them comes a kind of juice. They supply drink mostly, but the drink has very important things in it, one of which acts like the wood-ash that the women in Labrador get by burning wood, and which they use to boil up with seal oil or any old fat to make soap. As a matter of fact, that is exactly one thing that these little factories (or glands, as some people call them) do. They help make the fats into soap. Of course, you cannot actually boil anything inside the intestine, so they have to make a clever chemical stuff which makes soap in the cool. All these marvellous chemicals have long names, and I am afraid you will never remember them, so we will not bother with them now.

" You know how easily soap sinks into things. That is why it is so good for washing the dirt off your hands. Now big fat cells cannot go through living membranes, so all the fat you eat has to be made into soap before it can get through the walls into the canals. But most wonderful of all, after it gets through the walls, it is no longer soap. If it stayed soap of course it would get back through the thin wall again. But hidden right in the wall itself lurks a ferment which makes the soap back into fat just as it is getting out into the canal. So, of course, then it can never leak back again out through the wall—until it is fine enough to get down to the last tiny capillaries, and so out through the spaces between the cells, as I showed you, where only Whites and no Reds could squeeze through.

" No, you never find any soap in the blood, and if too much fat gets into the blood, do you know what happens to it? The cells are too wise to worry about it. They hand it over to another lot of guards, who just store it up on the outside. That is all very well so long as there is only a little fat stored up on the outside of the body, because it is the most perfect thing to keep the heat in. If you shoot a seal or a polar bear in the winter, it floats about on the surface of the water because in its body are some wonderful cells which tell the body in the autumn that the water is going to get awfully cold and freeze up. So it puts a thick layer of fat on, and that makes the body float. (Picture 130.) If ever you shoot a seal in summer he will sink to the bottom because there is no fat on him, and if you want to get his beautiful skin you will have to dive down after him. If you eat too much and exercise too little, as so many people do, soon you will have to drag about everywhere a huge weight which you can never lay down. It clogs up and weakens all your machinery. Every square inch of fat adds hundreds of miles of useless piping, which the poor pump will have to drive blood through. Never eat all you want. Fat people all die younger than they need. 'Always get up from the table able to eat more' is a golden rule.

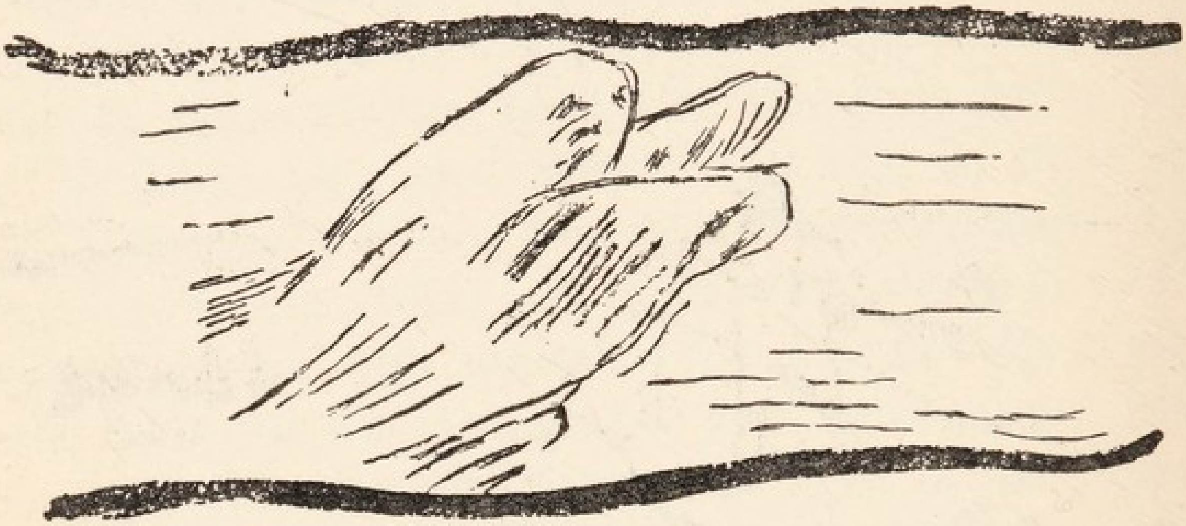
"I didn't tell you that in the first part of our tube there are offices especially for sending messages, like a secret police. Directly the big gates open and some supplies come along, messengers are at once posted into the blood pipes near by, and are hurried off to warn the drug shops and factories for chemicals. Oddly enough, these are called ‘ Secretins.’ They race off particularly to what is, perhaps, the most



130. The polar bear floated because Nature surrounds us all with warm fat in cold weather.

important factory in the whole body. It is called the ‘ All-flesh ’ or ‘ Pancreas,’ and is fixed right in the very middle of your body. It is carefully tied, close to the upright spine and padded round by all those beautiful slippery warm tubes called ‘ bowels,’ to prevent any cold or harm coming to it. The secretin says :

'Supplies coming along. Some of them are not ready for use. Please send workmen immediately.' (Picture 131.) There is a branch tube from this factory which leads the workmen to our big tube. We call this the 'Pancreatic duct.' Down it come tripping several kinds of mechanics. The

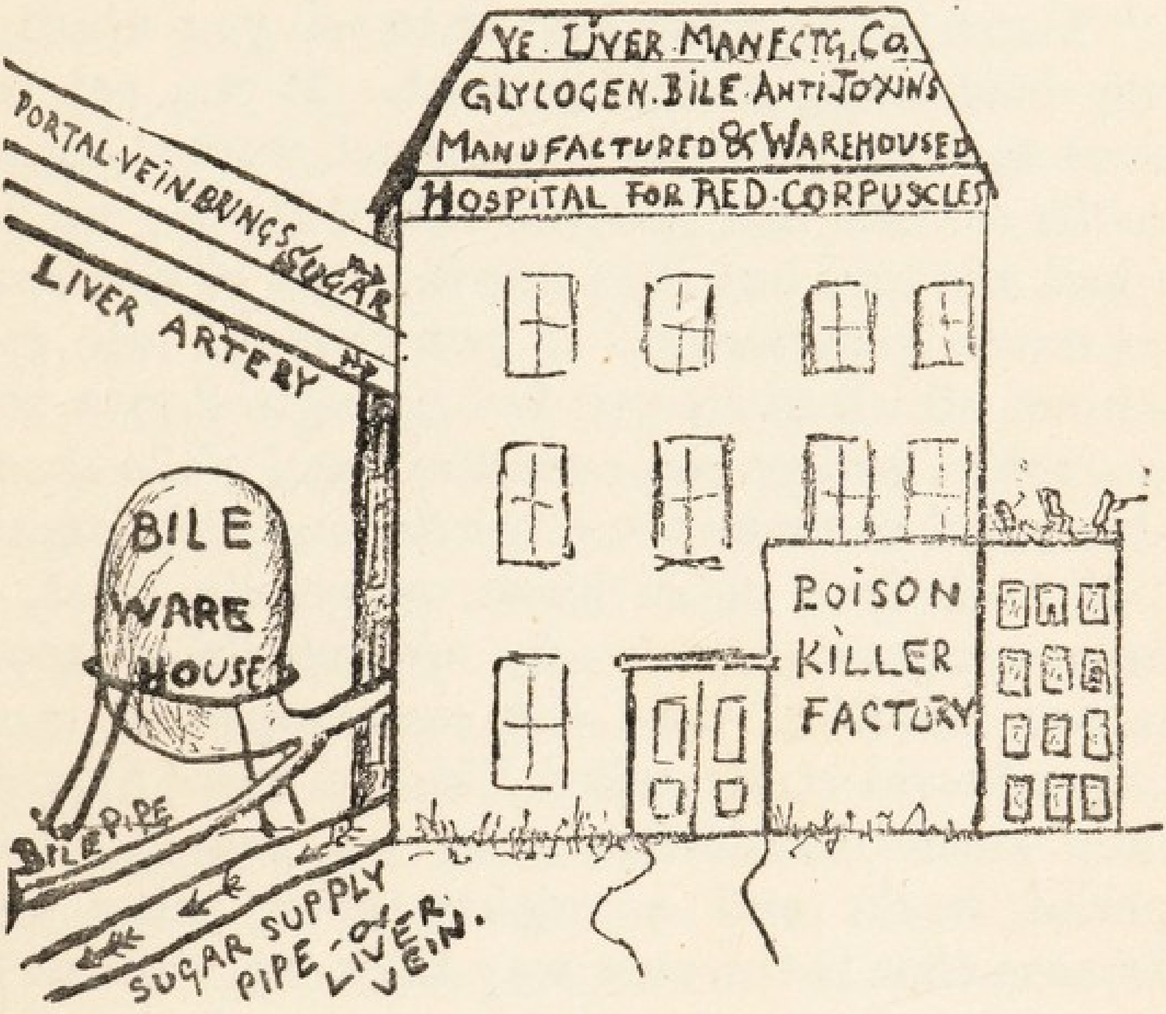


131. Secretin going to warn the pancreas.

first kind, oddly enough, are called 'trypsin.' They cannot do anything by themselves, but with the help of the little glands which supply them with a very powerful explosive, they tackle and break up any meats left, or any proteids. Another lot of workmen tackle any of the Starch Brigade that are left, and yet another tackle the fats, or what is left of them. Still another very important despatch carrier is manufactured in the pancreas. He is a shy, delicate fellow, and the others will not allow him in their roads, or ducts, at all. If he comes along, the others immediately kill him. So he creeps off, straight into the little blood-vessels, and travels only by the canals. This is the slippery fellow that Doctor Banting has just caught. He is born on islands in the big pancreas, so they christened him 'insulin.' He is the master trainer, which teaches that enormous factory, the liver, how to handle all the sugar in the canals. If he is not around, the sugar gets all blocked up in the canals, and then the blood gets full of it. Special messengers dash off at once to the kidneys for help, and they begin to pour it out all they can in the urine; but in spite of that the whole body gets poisoned. Thus it is that people with that trouble must not eat sugar, or starch, which all becomes sugar inside us. Doctors call the trouble diabetes. Now that we can catch these little sugar masters, and keep them in bottles, we can take a hollow needle and a syringe and force some of them to go into the blood canals, and away goes the diabetes, when lack of sugar masters is the only cause of it. It is just as if whenever the sugar stevedores in the canals go on strike, doctors could always send down a strike-breaker.

"Perhaps you would think that was enough to find in our tube? But really we have only begun. That great factory, the liver, has a large pipe opening into our tube. What comes in through it is called 'bile.' It is beautiful yellow stuff; though I will whisper this—that the colour comes from the remains of the poor old red corpuscles, which the liver has eaten up. But is it not a clever thing that even these remains are not wasted? The liver makes them over into very valuable helps to the pancreas. One squad enables those of its workers, whose job it is to hammer up fat blocks, to get much closer and grab them better; while another lot, called salts, hold the little pieces apart, and carry them through into the canals. Real 'old salts,' like Sinbad, aren't they? But they themselves do not go on the long voyage. Not they! Once inside the canals they drop their burdens and go quickly back to the liver factory to get a 'mug-up,' before they are ordered off down the bile duct once more, to the same old job.

"There is a rest period, as you know, between meals. But this bile work is a drainage system, and so must go on all the time. The result is that it must have a tank somewhere to collect it, just like the drainage tank in the garden. This is called the gall-bladder. Unfortunately sometimes the bile dries into little stones, and these get blocked into the pipe, and won't let the bile out, and then the whole body turns yellow. This trouble is called jaundice. The red corpuscles cannot rest up to die, or choose exactly where to die. Like us, most have to go on working, while others are dying and being buried all the time. The liver is their main cemetery. The spleen, which looks like a small liver, and is fastened near the stomach, is an overflow cemetery, as well as a factory for baby Reds. Here ends one life and here begins another. The liver is really a huge warehouse and an exchange store for



132.

everything, especially sugar, and electricity, and red corpuscles. (Picture 132.)

" Now to go back to our tube. It is surrounded like all the rest with muscle-cells arranged in layers around it, and also in long battalions all along it. They go on contracting, wave after wave, and driving the food material over the obstacles and between the pyramids, until at last what has not leaked into the lymph canals and blood pipes comes to the gate at the other end. They do it without our telling them, or even knowing about it. They ' work while we sleep.'

" There is one thing I want to tell you which is very interesting and important. If you eat too much meat or proteids you cannot store them up on the outside like you can fats. Storing up fat is bad enough, but it is much worse if you send too much meat along. It gets changed into real poisons, which make you feel heavy and give you headaches, and poison even the canal walls themselves, and so make them brittle, and they break. Too much food of all kinds, especially meat, is the commonest reason why we get old so soon. In our beautiful tube the oversupply of meat makes horrid stuffs called ' Indol ' and ' Skatol.' They smell dreadfully; and yet that is their special work, and a mighty good thing too. Because that is the only way they can warn us at once that putrefaction, or corruption, is going on inside you, instead of only fermentation. It is just like a lot of corrupt politicians instead of fine patriotic statesmen in the Capitol. In fact, in the waste which comes from our body, of all that we eat that is left over, a doctor can measure exactly the amount of putrefaction that goes on in the tubes by measuring the amount of a substance that these become. This is called ' indican,' which ' indicates ' the exact trouble. My advice to you is: 'Never eat meat more than once a day.' There are a great many people who never eat any at all, and they are just as strong and well as the others. Some claim that they are even stronger. The rest of the meat product that we can use is turned over into another stuff that can go through the wall into the canals. We call it 'peptones,' or 'proteoses.' It really gives us 'pep.' Acid Reds carry it into the wall, and while going through the wall, like fats, it also gets changed into albumin, a gluey-like substance, something like the white of egg. So it, too, cannot get out of the canals again. The liver warehouse stores some more of it with the same stuff made out of bread and potatoes. It is labelled 'glycogen' (which only means sugar-maker). If you are in a very hard race, or are taking a lot of exercise, like in a football match, the liver can, at a moment's notice while you are playing, pump a lot of it into your blood for you. A clever little fellow, a ferment, who lives in the liver, kindly turns it into sugar all ready to be used before it is allowed to go on. Then it goes straight to the muscles, where it is burned up very quickly and makes a great deal of heat and gives a great amount of energy, so that you can play up and kick the ball harder. In this way you can go on working or playing hard for a long while, and will not have to keep rushing back to get 'something to eat' in order to enable you to carry on.

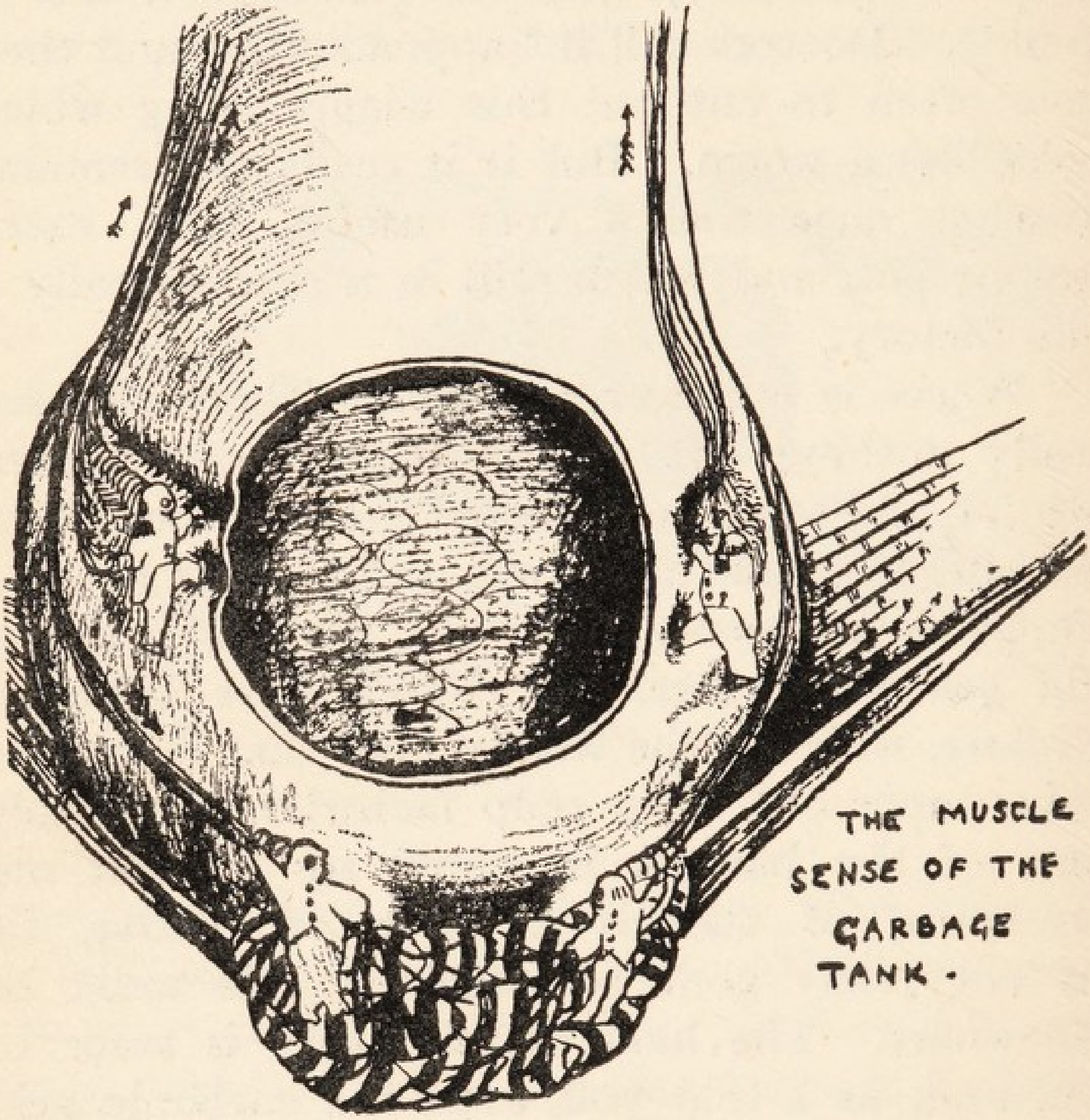
" Now we have come to the gate at the other end of this small intestine. It is called a valve, and it is a very large one. (Picture 133.) Once through that and we shall find ourselves in a

133.

large tube, about eight feet long. The valve is an odd one. It is like this. Whatever goes through it can never get back. It is easy to see how it acts. Also you see that there is a wiggly thing left on the left side, called the appendix, because, like in a book, it is fastened on to the blind end of the great tube. In the cow and all animals that eat only vegetables, the wiggly thing is a long bag. Into it go the grass and hay and tough food. It has to stay there a long time, because the factories find it much harder to break it up into useful stuff than they do our kinds of food, especially cooked food. Now on the wiggly thing in us 'No thoroughfare' is plainly marked up, and when things will insist on trying to go down there, there is generally a lot of trouble. Doctors call it 'appendicitis,' and they have often to cut out this wiggly thing which looks like a worm. But it is really the remains of what once was a very useful, long, extra cooking-pot, and which still in a cow is really a milk factory.

"Where is our banana now? There is practically nothing left of it. It has been turned into fat, and soap, and hustled through the canals, and burned up in the tissues, and there is nothing left but what seems of no use, such as carbonic acid gas and water, and tough fibre made of cellulose, which is the woody fibre that is used to make paper out of in pulp factories. Probably some of the banana is stored up in that old storehouse of the liver. Yet, of course, he has not really gone to nothing. He must be somewhere. The heat of the body is some of him, and, as I told you, even the carbonic acid gas is not wasted, for it is taken by that wonderful chlorophyll, torn to pieces and built up again into more bananas. Even the refuse, such as the peel and stringy part which our bodies cannot use, goes with the manure into the ground to build up a new banana-tree. So that is how carbons, hydrogens, oxygens, and nitrogens all go round and round, in one of the most marvellous cycles in the whole world.

"I must say one thing about this last eight feet, or large intestine. Even there, nothing is



134. When the Upper Guards feel it pushing they wire to central for help—central wires the Lower Guards to open the gates—the tank is held up in a sling.

wasted. Of course it is really the cesspool of the body. But it is mighty useful all the same. To begin with, it is very usefully wrapped around all the delicate parts of which we have been speaking, forming great big cushions, which keep everything nicely and firmly packed and thoroughly warm in our bellies. We could not run and jump and tumble about as we do without hurting all these most delicate factories about which we have been talking, unless we had this perfect buffer. Nature hates waste—so do all decent people. We haven't any right to waste anything when so many people need things; and this old cesspool knows that, and it does a thing which is not done in any other part of the whole machine of the body. It hasn't any ferments of its own, but it is very patriotic and wants to get everything that it can for the body out of the slops that come through the big valve door at the end of the small tube. So, first of all, it houses very large numbers of tiny animals called 'bacteria'—millions of them. They help to tear up, by means of chemicals, anything left and to form the enormous bulk into hardish balls, which roll and squeeze thoroughly the rest of the material, and then the big tube rolls it down, not only one way as before, but also back again the other way—to and fro, to and fro, something like a washerwoman does in wringing her wet washing to and fro. At last, when it reaches the lower end there is no waste whatever, if your body is working right, and one-third of what we pass away is only dead bacteria. All the rest has been used.

"When it reaches the end, messengers at once warn you to go immediately and let it escape. Never neglect to do so. A perfectly healthy person should empty the big bowel as regularly as clockwork, every morning and every evening. If you do not feel this warning, something is wrong. Go anyhow, and wait on nature. To stay constipated is to risk poisons getting into your system which should be cast out.

"Isn't this a wonderful story? It is wonderful because all these marvellous machines with their delicate functions and useful products are all alive, and have to be kept so, day and night, whatever we are doing, wherever we are; and yet they must never be put out of action by the tremendous amount of knocking about which we give them.

"There is one other thing you ought to understand, and that is how you are to know if you are putting too much or too little into this machinery. You cannot measure the amount of fuel that you are supplying to your machinery by feet or inches, or by pounds and pints, or by dollars and cents. We have to have some other kind of measurement. So we have been obliged to invent something which we call 'calories.' It sounds like 'Alice in Wonderland,' doesn't it? Since we must keep our bodies hot or die, we can measure the value of everything given them by the amount that it can heat, whether it is an egg or a turnip. One ton of coal will only give that ton's equal in heat. One sterno can will boil only so much water. Coal is only stored-up sunshine or heat, and it can only give out what it took in. One gallon of oil burned will only drive the car so many miles. Now we cannot say a pound of heat or a pint of heat, so we call the amount of heat that would warm a quart of water one degree Centigrade, a calorie, which is really only the Latin for one heat unit.

"It takes about three thousand calories a day to keep my body right in ordinary weather. Big folks, hard work, and cold weather use up more than little folks, warm weather, and loafing. But it is easy for anyone to tell how much they ought to put in the body, because you can get a list which shows you exactly how many calories anything gives you, from a slice of beefsteak to a cup of milk. You can also get a list of how much you should take for your size and circumstances. This is exactly like an exposure meter, which tells us how much sunshine a film needs under every kind of circumstance to develop properly.

"You have to keep up the heat of the body or you cannot have strength and energy. If you do not keep the fire under the kettle, there will be no steam to lift the lid. If you let the furnace go out, there is no steam in the pipes, and any machinery will stop. Once at sea I had to burn my deck to keep my engine running till I reached harbour. If you do not eat food enough the body becomes a skeleton, and even the bones waste away; that is to say, it is all burned up to try and keep the heat up. That is what happens when people starve. On the other hand, when you eat too much, everything gets stopped up, and your body gets as fat as a Christmas pig, and a horrible burden to yourself. So watch your diet, learn self-control, and pass a law of prohibition against your own mouth when you have had enough." (Picture 135.)

135. Fat as a Christmas pig.

CHAPTER XVI

THE SPECIAL SENTINELS OR CONTROLS THAT HELP US GUIDE OUR MACHINE

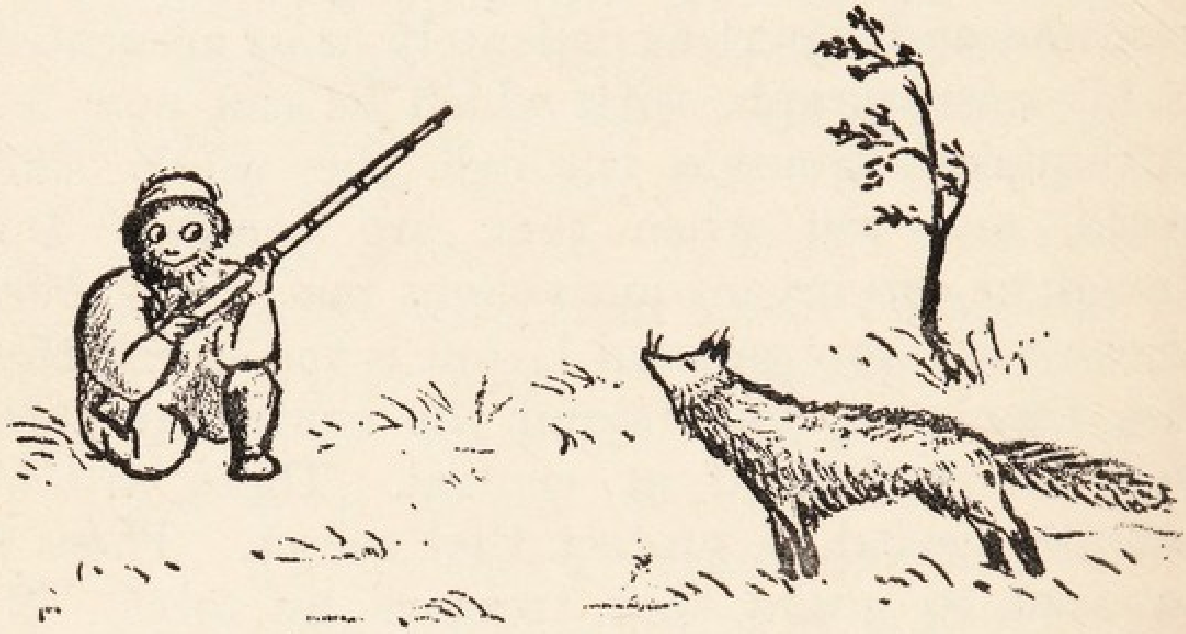
" THE controls are of two kinds : the ones you and I have a share in—and those we don't. We share in at least six controls—seeing, hearing, smelling, touching, tasting, and voluntary muscle control. In the pumping, balancing, heating, draining, and vessel management, and many others, we have little control or none. They need an exactness we could not give. All messages from eyes, ears, nose, tongue, or touch-cells are sent in cipher to us and need interpreting. They travel by wire to central at about 426 feet in a second—a million times slower than electricity. All these sentinels do is to make each their own kind of picture on a sensitive plate in central, and somehow you and I interpret it, exactly as we do a photograph that goes by telegraph. But remember that our eyes don't see, or our ears hear, or our hands feel. You and I do that."

" How do you know that, father ? "

" Well, take any one of these five machines—say the eye. It is nothing but a camera—a picture-machine. Cut across with a razor blade the 500,000 wires to central, and leave everything in the eye exactly as before. Now there will be no picture in the central office, though there is the same picture there on the sensitive plate in the eye. Result: we are blind. Just so you can send by machine your own photograph by telegraph to New York any time, but if the wires are cut between, the man in New York can interpret nothing. No more can you and I in our central office, with our wires cut. It is the *man in the office*, not the machine, that sees. Sometimes a little thing wrong with the machine makes us interpret wrong. Thus some men see a red light and think it is green. We call that colour-blindness. To-day they are trying to put a whole pig's eye fast to the tiny nerve of a man's eye, when his eye has been destroyed. But if they succeed the man will interpret as before, and will see to read, to know loved faces, and not merely see as a pig sees. The eye merely makes the picture. And the same is exactly true of all the other senses. For example, the ear. The telephone doesn't hear—cut the ear-wire to central, and no one hears. It is the living girl in the central office that hears. All this is wonderful enough. But beyond that, the man at central, having recognized how limited his body's instruments are, now makes new ones so that he, inside, can have more power and scope. With his telescope he sees farther off, and with his microscope far smaller things, and with his X-ray he can see through solids. With his microphone he hears inaudible sounds. With his telephone he hears infinitely farther than before, and with his radio he catches floating sounds from the air, to the existence of which his ears give him no clue whatever. His sense of touch can't measure a ten-thousandth part as delicately or as accurately as his seismograph, with which he can now feel earthquakes tremble through the whole solid world, and tell when they are coming. But though he can invent marvellous machinery, even he can't tell how you and I, that is the spirits that own the brain, understand the control pictures that are registered at central. There are no patents needed to protect that secret. There is no need to guard that treasure by force. No man ever expects to understand how you and I or he interprets, any more than he expects to know who you and I are; where we come from; or where we go to when the whole machine is worn out and we have to go and look for another, like the hermit-crabs do when they get too big for their shell.

"Now let's look at the smell control first. How does this machine work? I've told you that everything we know of in this world depends on movement for existence, and all these controls depend on movements that make pictures, like my hand moving my pen along makes these words, which form pictures in your eyes and are then wired to your brain, and you interpret what

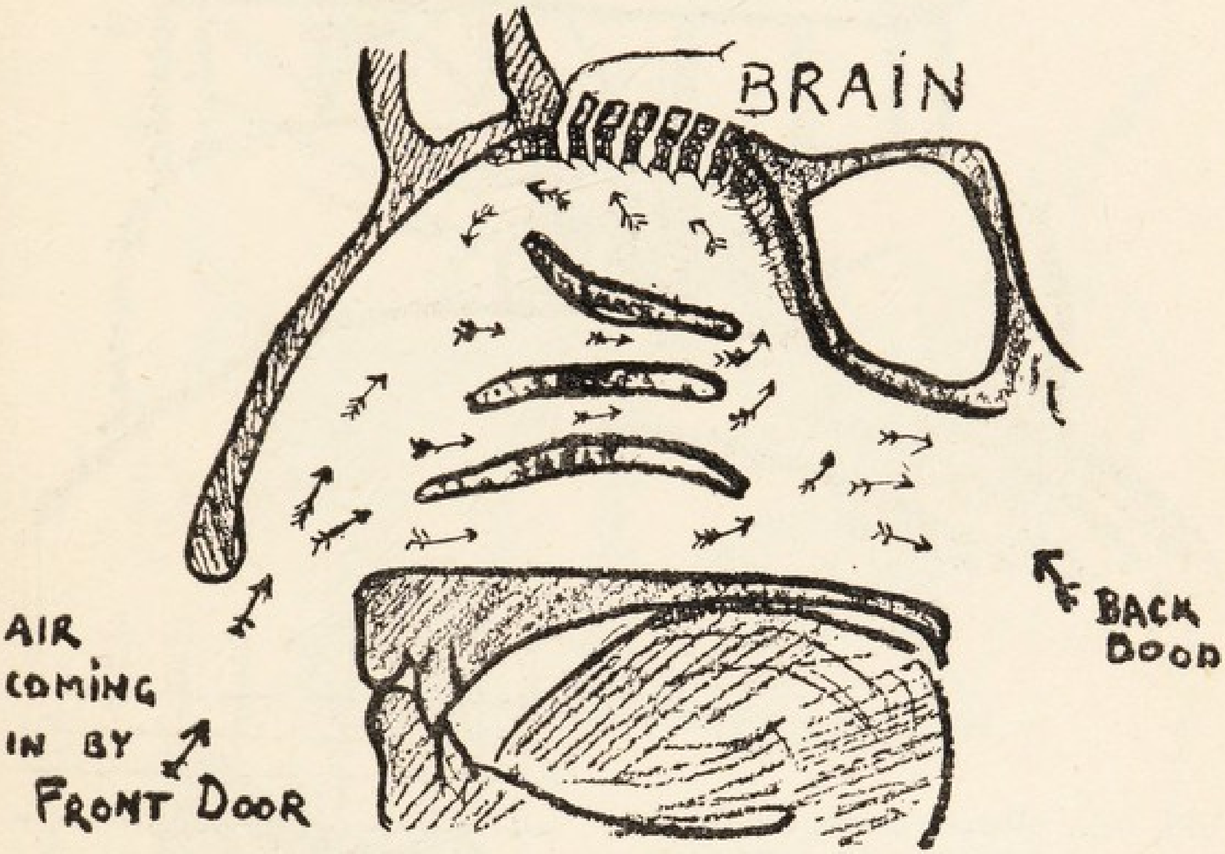
I want. You call that 'reading.' Now the smelling control is a very accurate and very simple machine. Some animals trust to it more than to any other. Clever as Reynard the fox is, I have seen him walk right down and over an open



136. Reynard the fox trusts too much to his nose.

marsh into the very arms, almost, of a hunter, who was kneeling perfectly still and making a chirpy noise, like a mouse in the grass. The wind was blowing the smell particles that come off even the cleanest man, like off everything else, in the opposite direction. And Reynard was trusting entirely to his nose and not to his eyes. (Picture 136.) I have lain out in a flat marsh and shot at a herd of deer. The smoke of my rifle was quite easy to see. But the deer stopped —looked at it, and then came right on near me, with their eyes wide open and their ears alert. The smell particles were again blowing the other way, and they did not trust their eyes. No one control should be trusted. Look at this glass of water—will you drink it?"

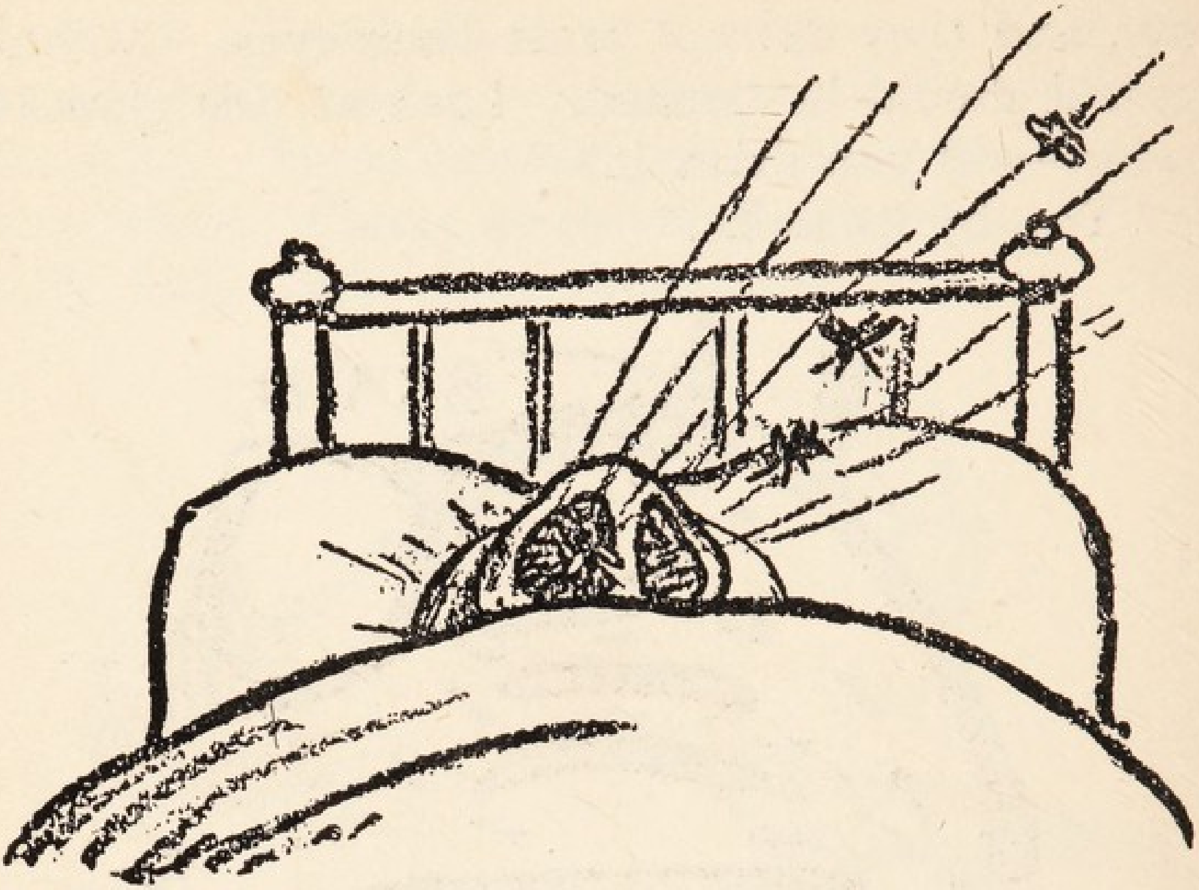
"Yes, by its looks."



137

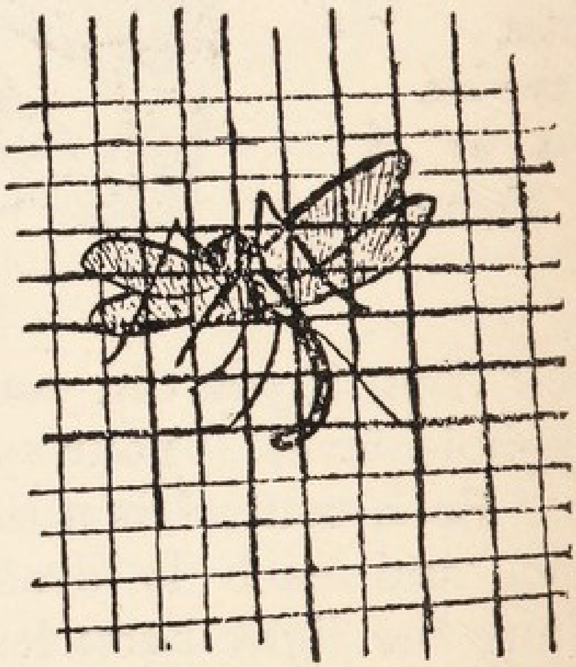
"Well, if you did you would very likely die of typhoid fever. Your eye can't see the germs.

"Each control is a machine, and an imperfect one, and each is dealing with violent forces. Thus the light particles of a brilliant lightning flash can destroy the eye, the smell particles of a skunk can kill a dog, the sound-waves of an explosion can burst an ear-drum, the speech control can, by singing the right note, break a glass bowl, or break a heart, or control the mind and the soul of others.

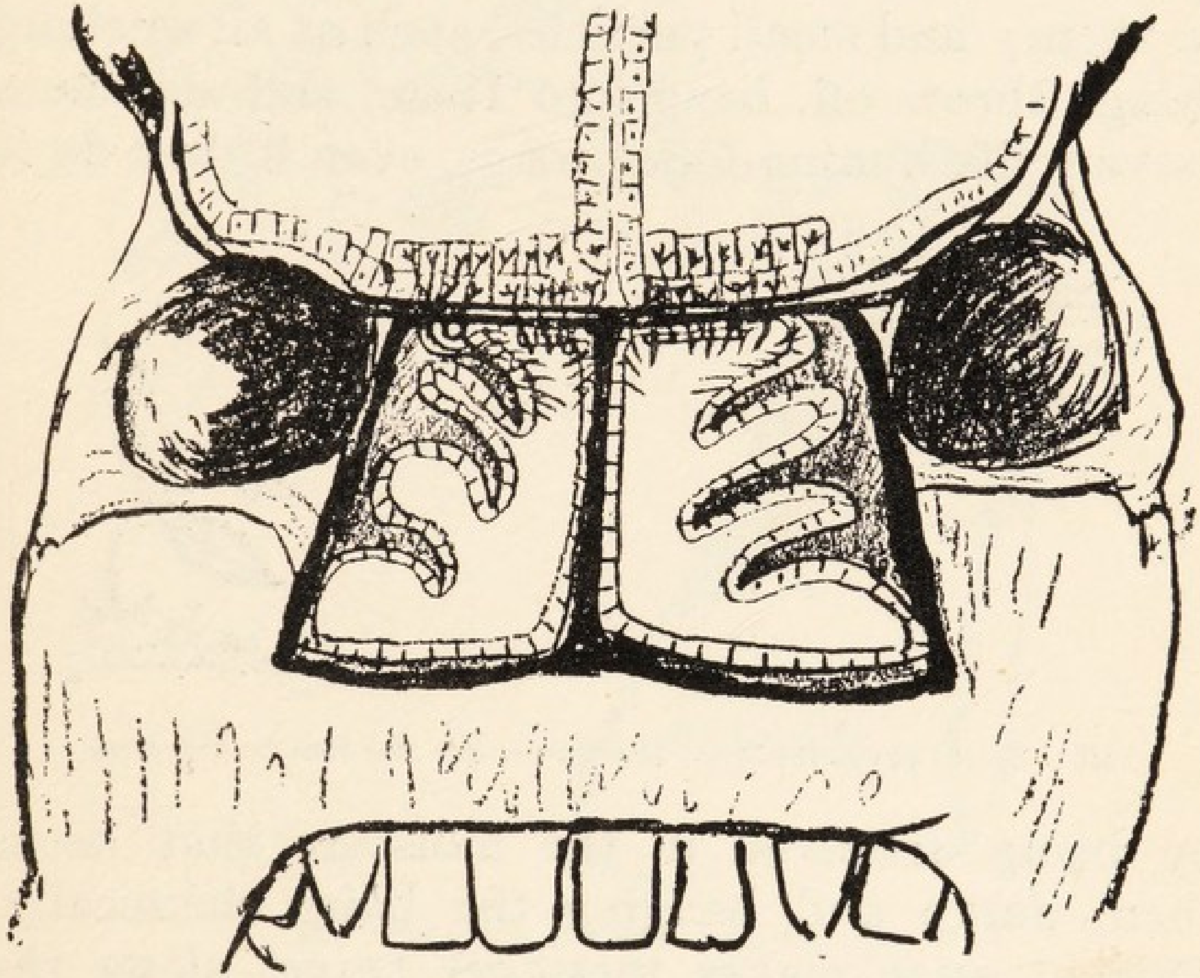


138. (*a*). Short, strong hairs to keep out flies and dirt.

138. (*b*). The hairs of the nose keep out all enemies like mosquito-wire does.



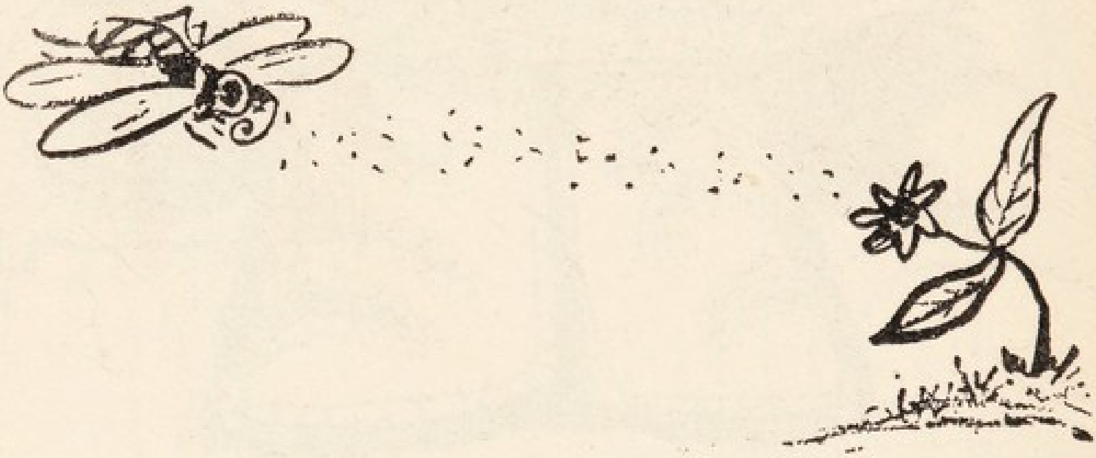
"All the control machines are closely guarded, like King Tut's tomb. In the smell-machine small particles are first sniffed up through two doors, called nostrils, which can open and shut as a first guard. Then in the chamber inside are lots of short hairs to filter or keep out big strangers that might do harm, like flies or dirt. (Picture 138.) The linings of the chambers are all wrinkled up to make a big surface over the hot pipes that warm



139. The cells of the lining membranes are connected by wires with cells in central.

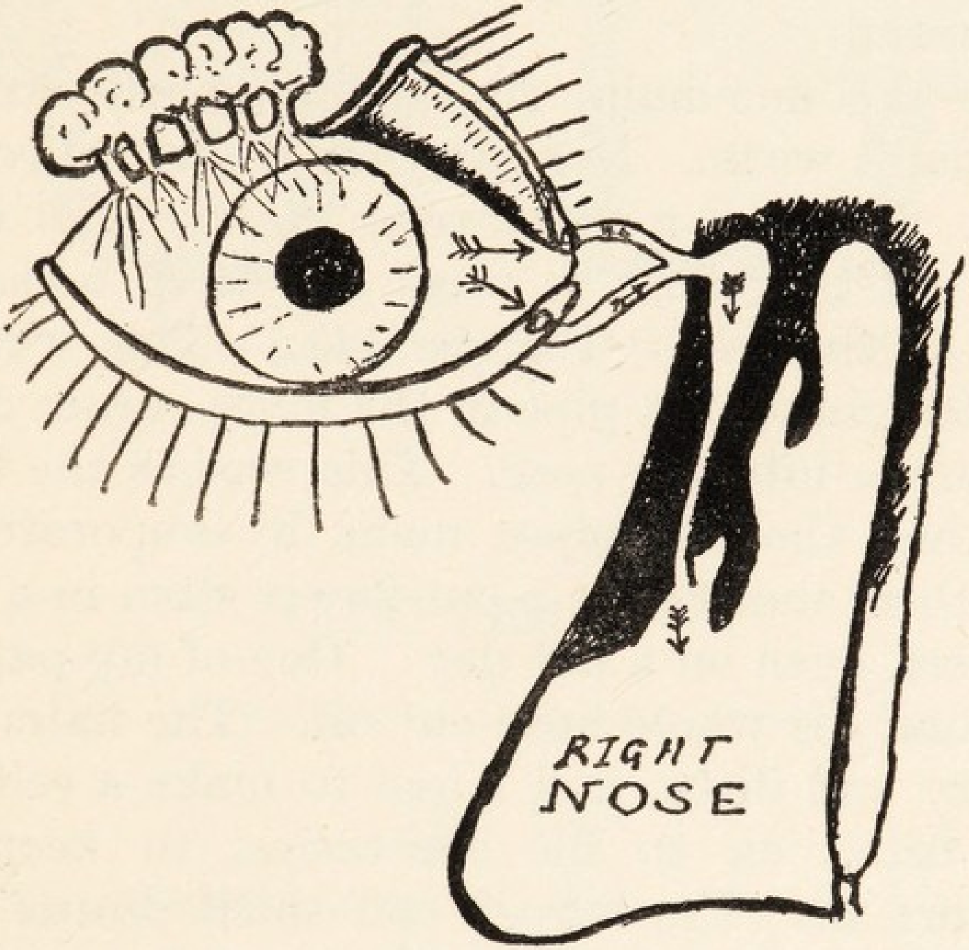
and moisten the air as it comes in. Over these are again spread guard cells, that throw out a sticky jelly called mucous, to glue little germs and dirt into bundles so that our lungs, or force pumps, can drive up blasts of air through the back doors into the chambers and blow the whole lot out, and so get rid of it. We call that ‘sneezing.’ A cold is caused from failing to get rid of germs.

Then higher up, right at the very top, are a lot of fine cells from which are wires going right through the bony ceiling, which is the floor of the skull. They go in groups, direct to central. (Picture 139.) These cells have very fine hairs on them; and small particles, such as all smelling things throw off, bang into these, and set them moving like tuning-fork prongs, even if they do it



140. Smell particles from the flower hit the bee on the nose.

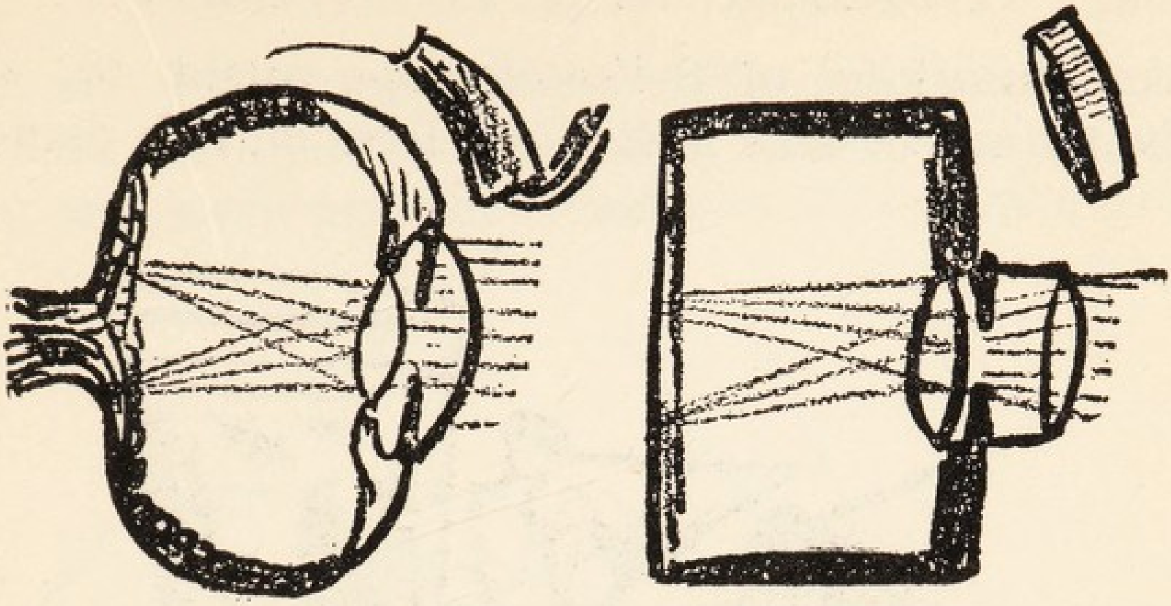
by being dissolved in the moisture that keeps them damp and banging the hairs chemically. This at once makes messages travel along the wires to central, and as they arrive, a picture of the smell is made on the records of the central office. That is how you know the smell again; *e.g.*, like violets. The record offices are called 'memory.' They are real records, lasting as long as central lasts. If you destroy them, then central cannot recognize a sweet rose smell from a bad drain odour. And lucky for us it is that our smell centre isn't like a bloodhound's or a setter-dog's. The air is probably as full of smells as it is known now, by the radio, to be full of sounds, and if we could smell them all, we would have to go about with croquet clips on our noses. As it is, we have



141. There is a sluice over the eye.

taught ourselves not to notice some smell pictures, while we have taught hounds to notice them, however faint they are. Have you noticed how dogs won't eat anything hardly, without smelling it first. We would hardly dare to smell at each dish that the waiter hands to us at a dinner-party. By neglecting to educate the smell-cells, however, our noses fail to notify us of even some of the worst gases; we may lose our lives as the result. Still smells do often warn us of danger long before we ever see anything. For example, a poisonous drain, and we can still discern one eight-millionth of a grain of musk, and it is said one twenty-five trillionth of one of mercaptan.

"If the fine hairs on the lining-cells dry up, they can't work. Nor can they if dirt collects on them. There is a sluice over the eye that sends water all the while to wash and keep moist the front of the eye. (Picture 141.) This water is then led through a pipe in the inner corner of the eye, down into the nose. This washes the hairs, and then the hot pipes make it evaporate and keep them moist, like a cut-flower stem in a glass of water, even on a hot day. One of my patients once had his whole nose cut off. The hairs then got dry and dirty, and I had to make a celluloid nose fitted on to his spectacles, to keep the moisture in. I'm sure I can smell dinner—run away and get ready for it."



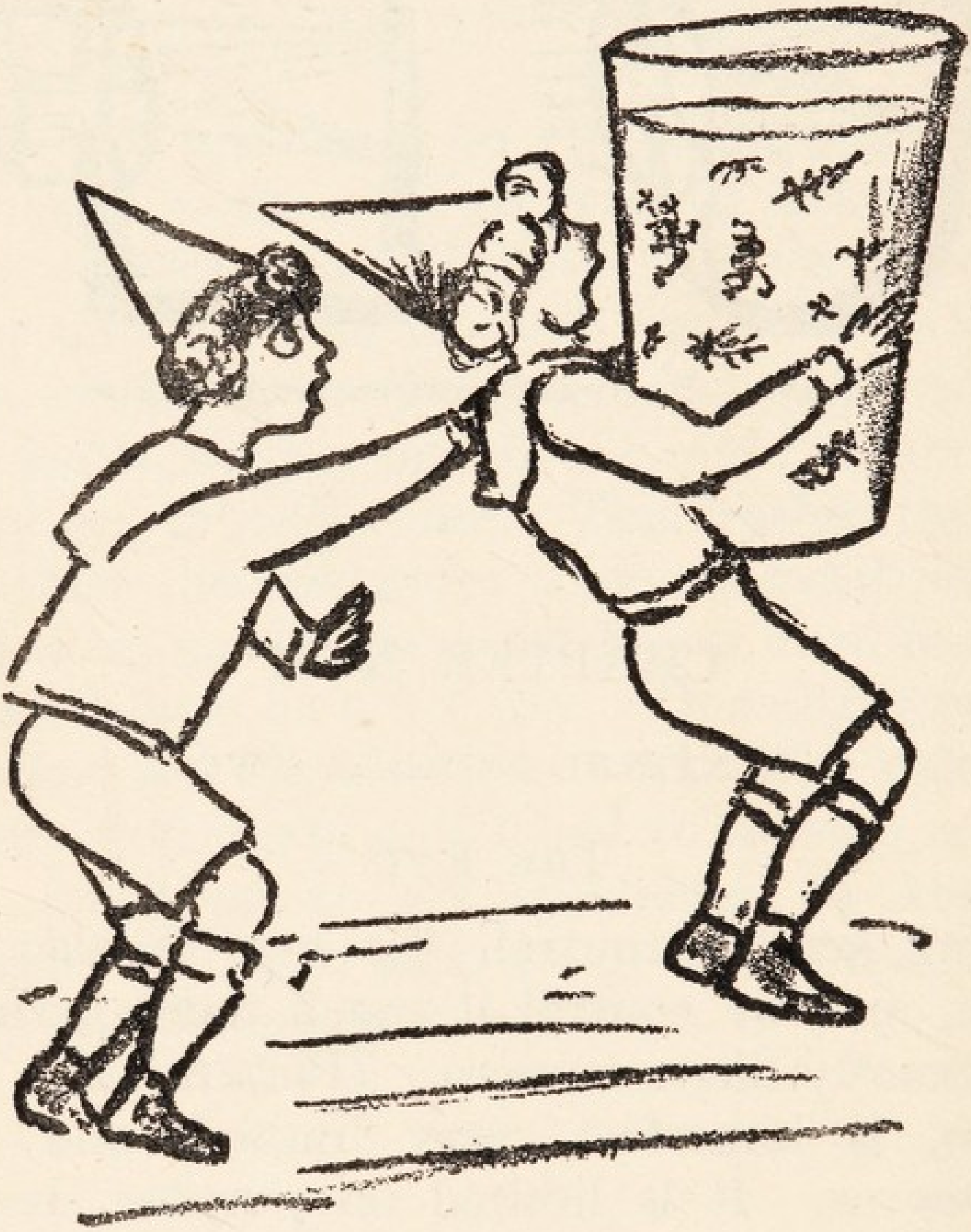
142. An eye and a camera are just alike.

CHAPTER XVII

SENTINEL NUMBER TWO

The Eye

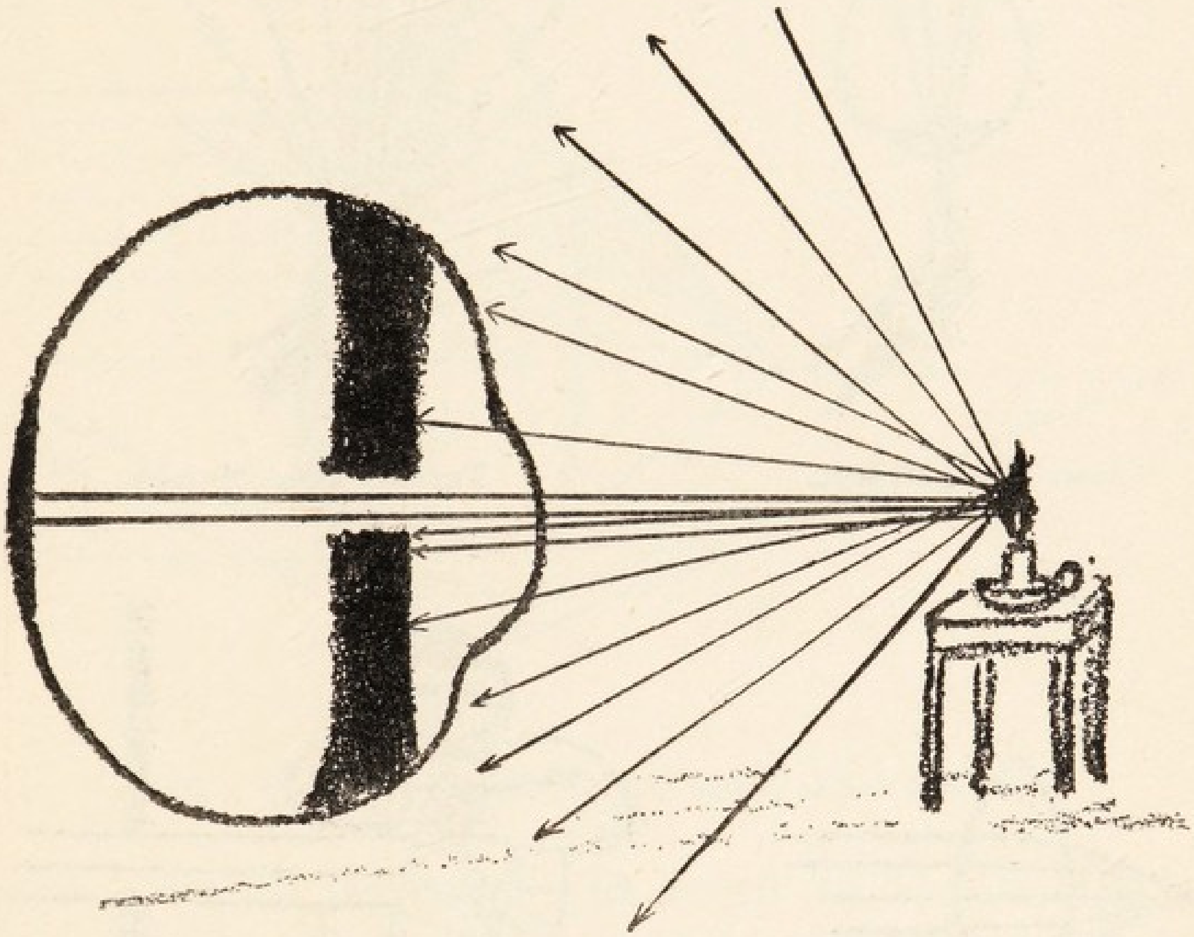
"The second control, the eye, is also very simple, and we control it much more perfectly. It is exactly like a camera. (Picture 142.) But it, too, is imperfect, very limited, and often deceives us. It is limited on purpose, because if we walked about seeing like a microscope we would be frightened to death by the sight of the millions of dangerous germs that are in our air, our water, our food. As it is, we see so much dirt in those rays of light coming in through the window that we almost hate to breathe it in. While if we saw all the things that are in our atmosphere, like a walking human telescope, or like some kind of radio-telescope might do, we should not be able to live our lives on this planet



143. If we saw every microbe, we should be frightened to death by the myriads of germs.

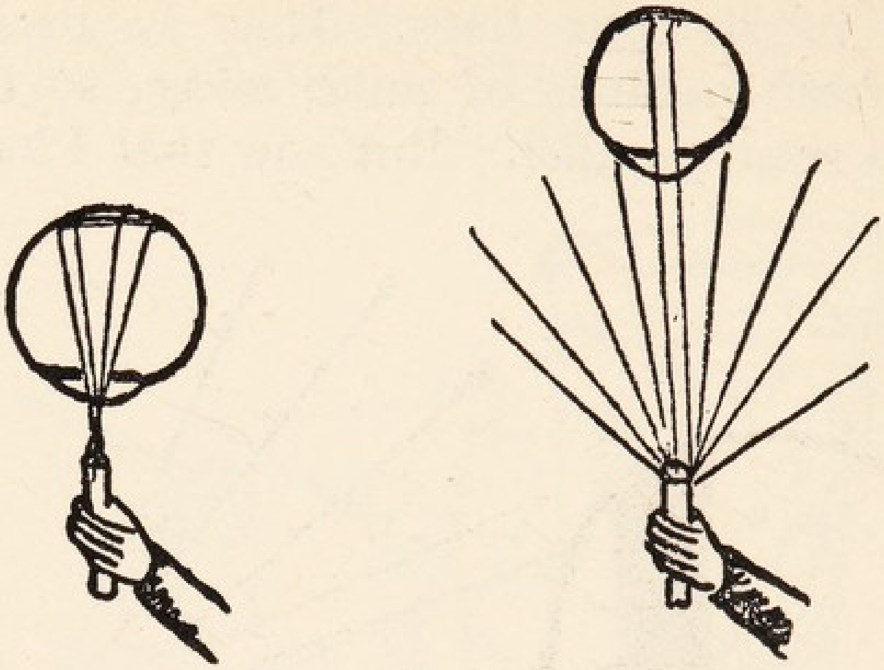
at all. As Einstein shows, everything on this earth is relative, and our powers have to be relative, too, or we couldn't exist here.

"Now look carefully at the light coming in through this slit in the window. See how it travels in straight lines. That is because it comes from millions of miles away, so that all the rays seem parallel. But now that I have this

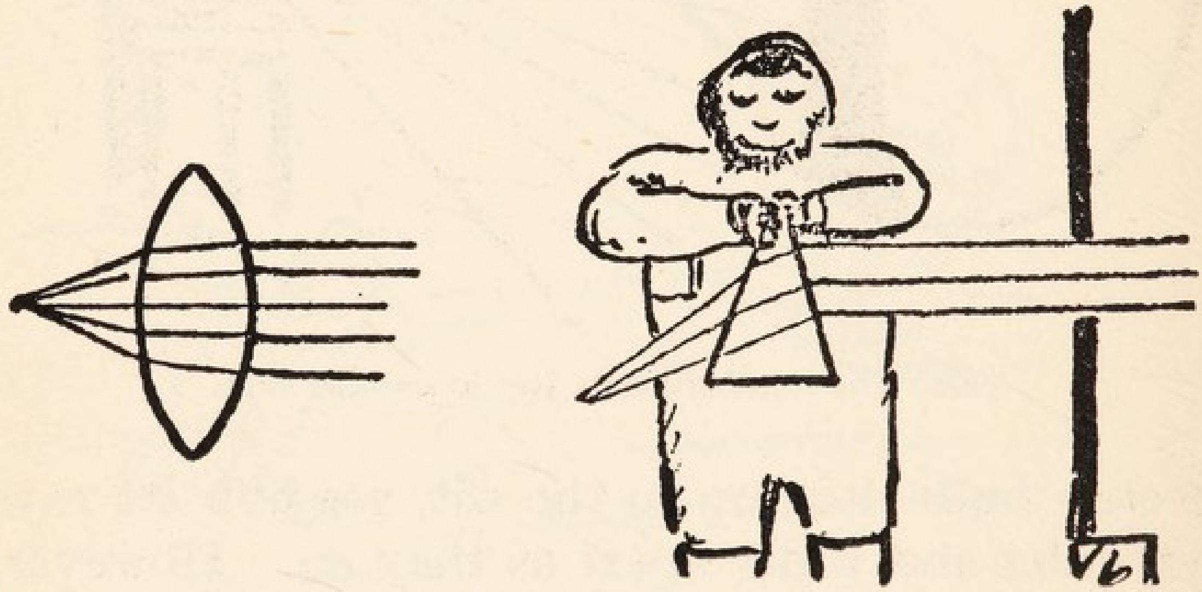


144. The small slit only lets in parallel rays.

electric bulb close up to the slit, see how its rays get wider and wider apart as they go. However, practically all light rays entering the eye from over twenty-five feet away are parallel, because the opening of our eye-shutter is so small it really only lets parallel rays in. (Picture 144.) Now you see this prism or lens. See when it stands in the way of the rays how it turns them? They can't travel through glass as easily as through air, so the rays on the outside, only having very



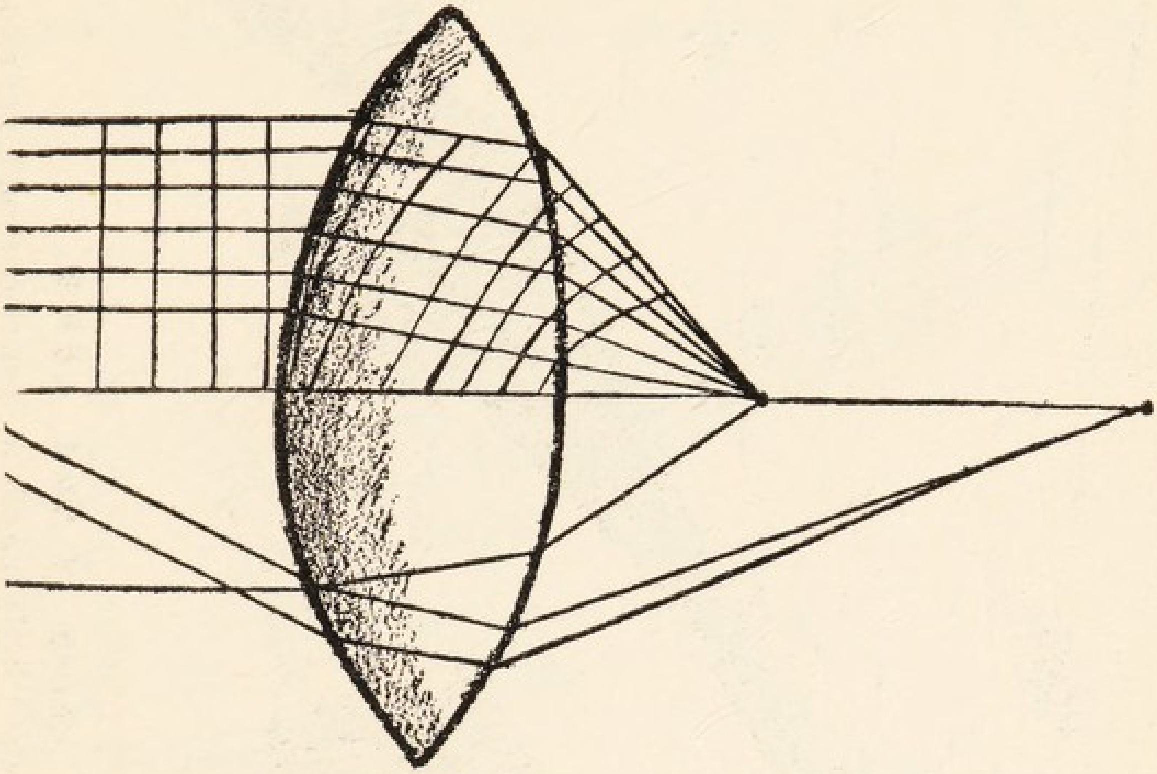
Closer than 20 feet. Further than 20 feet.



145. Bending the rays.

little glass to pass through, go quicker, and the column of rays gets bent, as you see. It is like a regiment of soldiers marching straight ahead and coming to a marsh. Those who have only a little bog to pass through get ahead of those who are in the bog longer. (Picture 147.)

"This makes the outside men curve toward the centre so that eventually all will meet in one point. This is called the focus. (Picture 146.)



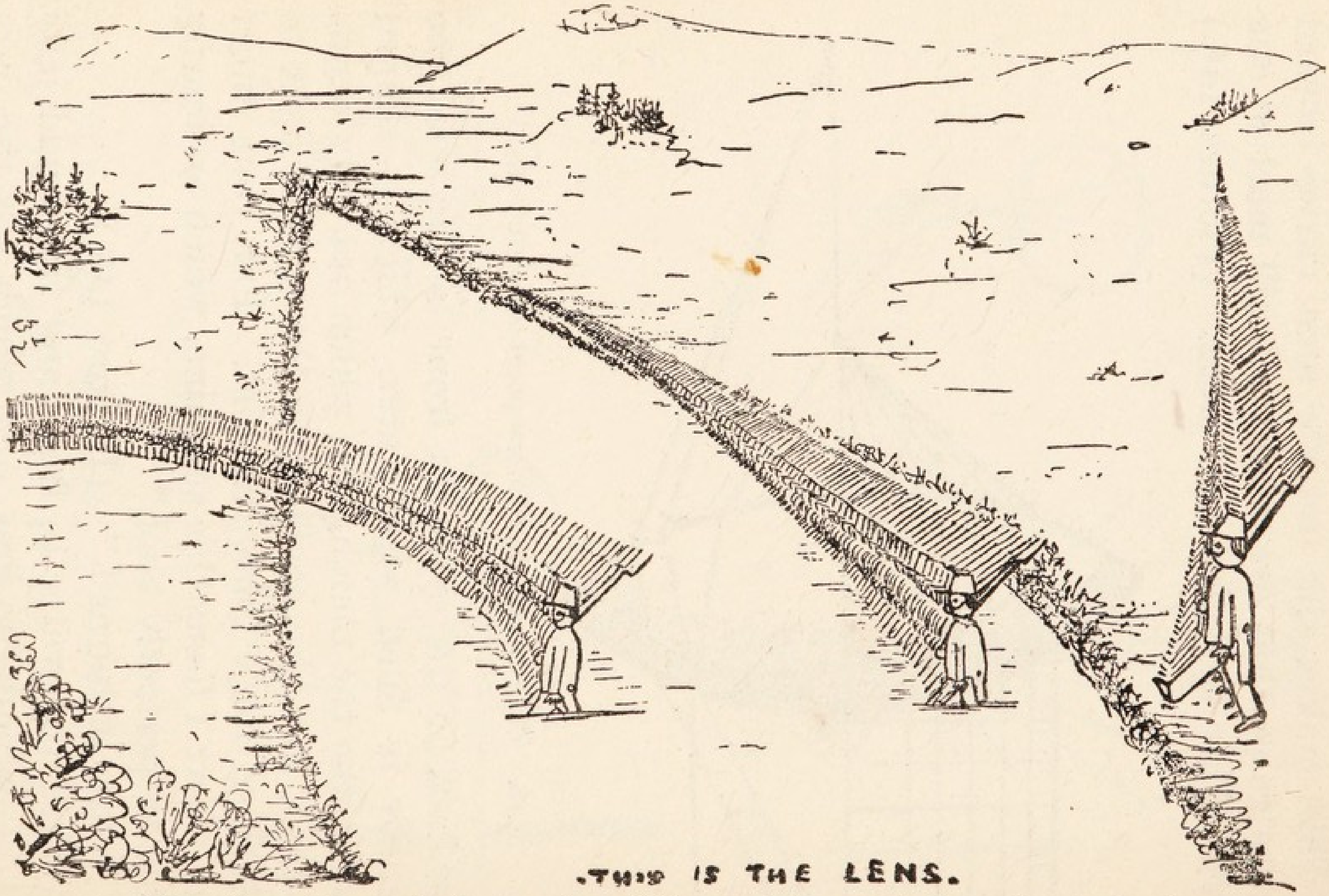
146. The rays all meet in one point called a focus.

Now look at the eye. In front of the lens, the chamber is filled with water, which is shaped exactly like the marsh, and which not only bends the rays, but also cools down the rays of light so that they don't burn the film. Put your finger here, where I focus this sunshine, which ordinarily seems so perfectly cool."

"Wow, it burns!" (Picture 148.)

"Well, the water in front and the liquid jelly that is behind the lens, and which fills the dark chamber, prevent that. The dark chamber is lined with black cells."

"Why?"



147. The soldiers who have only a little marsh to march through, get ahead.

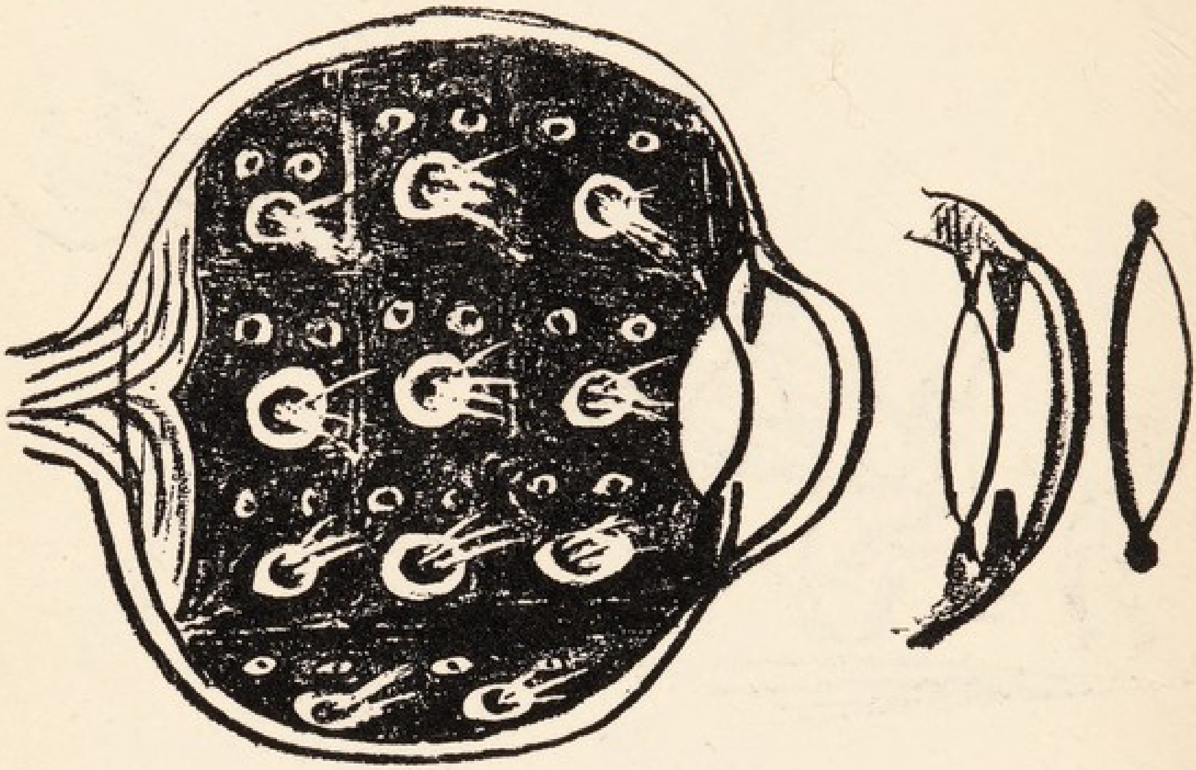
“ Well, just like the camera. If it were lined with looking-glass or white, there would be confusing rays of light reflected by the million, and your picture would be spoiled. But those black fellows that stand all around the chamber,

148. Focussing.

shoulder to shoulder, literally swallow all the rascally rays that creep in at wrong angles. (Picture 149.) Men with black skins don’t burn even in Africa; their skin takes the rays right in.”

“ What’s the good of the inside lens?”

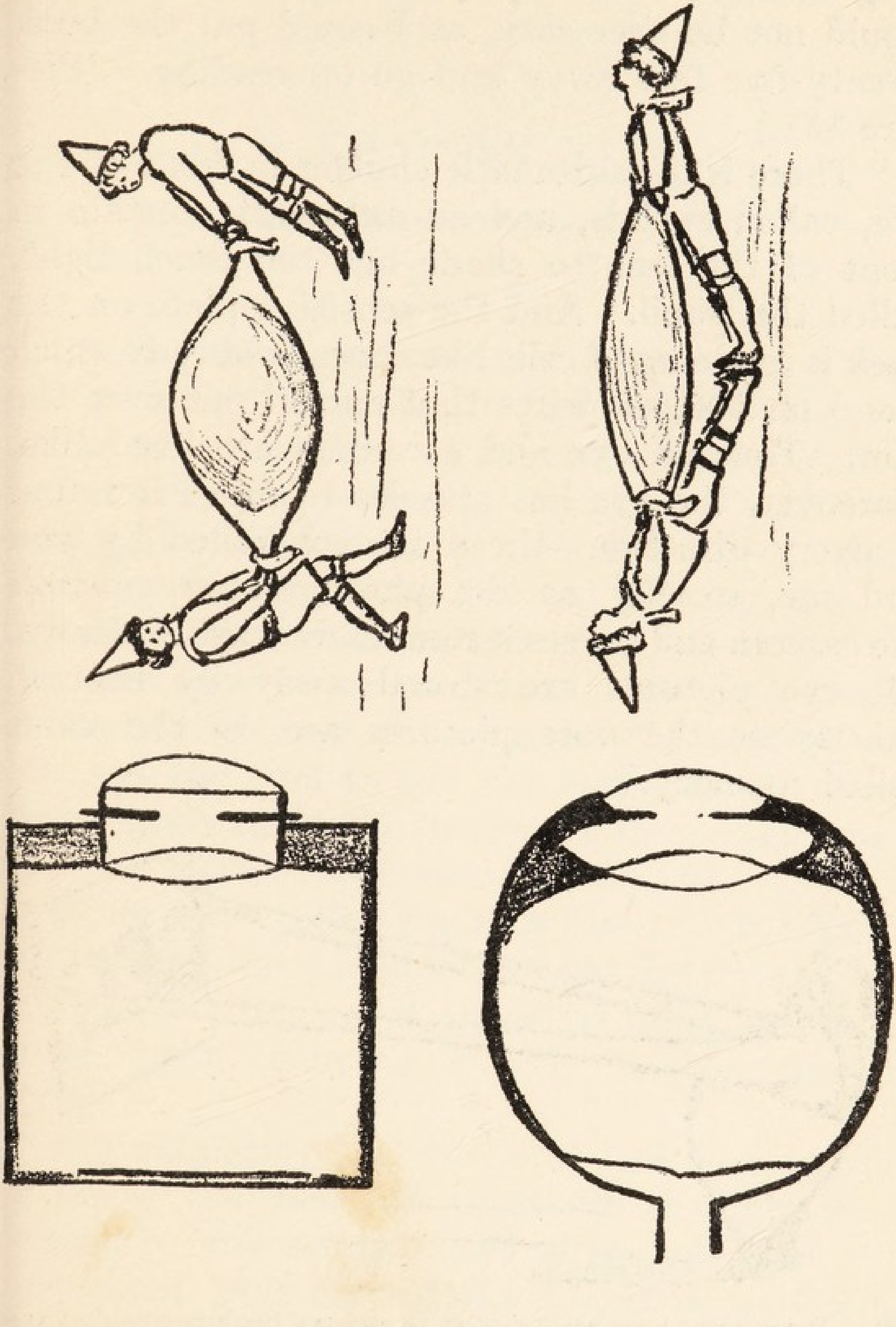
“ Oh, lots of good! If all the objects we want to see were always the same distance from us, it would not be needed, but they move nearer or farther from us, and our eyes want to follow them —so as the rays are one time coming wider and wider apart, or more and more parallel, according as the object gets nearer or farther off, the lens must get thicker or thinner, as the case may be. There is a ring of muscles all around the bag in which the clear elastic ball, called the lens, hangs. This flattens or lets the lens get rounder



149. Inside the dark chamber the black cells swallow all the wandering rays.

again, by pulling, or not, on the edges of the bag. But you and I have no kind of control in that. (Picture 150.)

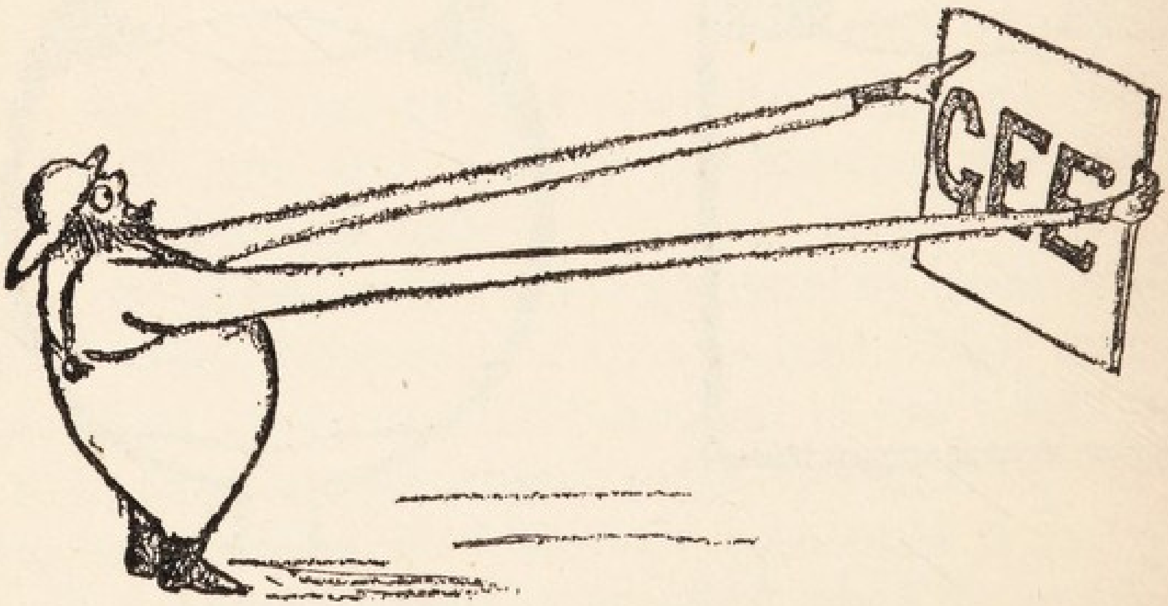
"As we grow older, the lens gets so tired out that it won't bounce out into a ball shape any longer, but stays too flat—and so it can't make the rays from a near object meet on the sensitive plate, but behind it. So now whenever I have to hold a book to read it at all, I have to put a new fat lens in front of my eye to make up. We call it spectacles. Of course if my arm were



150. Pull on the bag and the elastic flattens out.

long enough, and my print big enough, that would not be necessary, as I could put the book twenty-five feet away and go on reading. (Picture 151.)

"There is an automatic shutter in front of the eye, called eyelids, and an automatic curtain in front of the lens to shade out too much light, called the pupil. And the sensitive plate on the back is made up of cells like cones, and rods which stand on 500,000 wires that spread out over the film. Thus an eye and a camera are just alike. Moreover, the eye has muscles to move it round in every direction—these are controlled by you and me, exactly as the photographer controls the camera and moves it round any way he pleases. All eye pictures are stored away by central, exactly as the nose pictures are, in the vault called memory."



151. If my arms were long enough to put my book twenty-five feet away, I could do without spectacles.

CHAPTER XVIII

SENTINEL NUMBER THREE

THE EAR

"THE third great control is the ear. The ear is a double control. It first enables the body to balance, and second it acts as a very valuable alarm, because while the eyes guard right ahead only, the ears guard in two directions. Horses can move their ears around in any direction (Picture 152), and can therefore tell better than we can how far off and from what direction the sound is, because of the angles the muscles have to put the ears to get the sound best. Horses rely much more on their ears than their eyes—so do rabbits and deer. They will hear the crackle of a single twig in a forest. Our Eskimo dogs hear the sound of a fight better than our fishermen can, and dash off to take part in it a mile away, running exactly in the direction of it.

"Fortunately as our ears are on opposite sides of our head, it takes sound-waves longer to get to one ear than the other, and that helps us to tell how far off the sound is, and which direction it comes from. Our hearing-machine has on the outside a half-horn to collect sound-waves and send them down the hole into a tube,

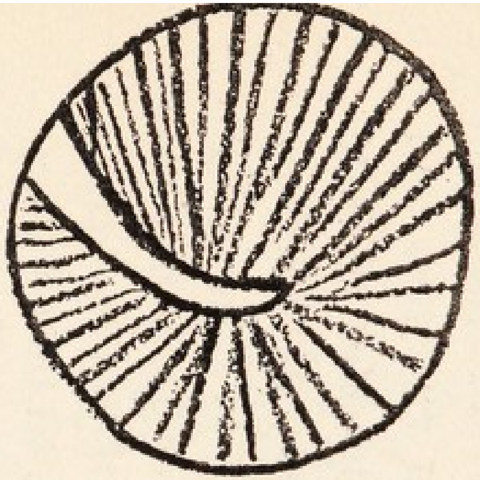
152. A horse can turn his ears in either direction.

as the receiver of a telephone does for our voice-waves.

"The tube is located in solid bone; and away down it, so as to be safe, a drum-head is stretched right across the tube. In the tube, also, are hairs and wax to catch and keep out enemies and dirt.

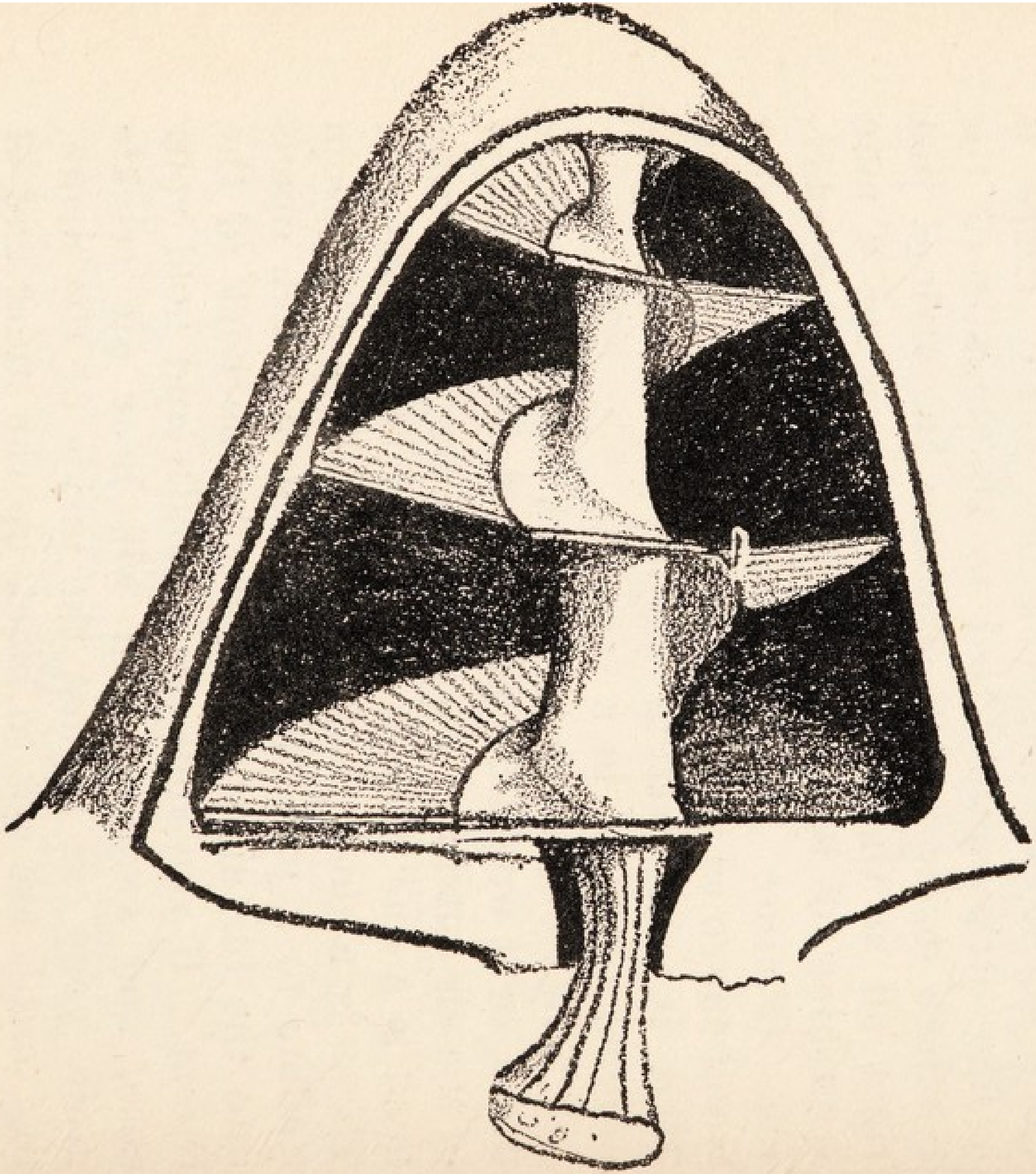
The drumhead is built up of very fine strings stretching from the sides of the tube and fastened in the middle to a tiny bone rod, called the hammer handle, because there is a knob on the top end of it. The handle is not exactly in the middle (Picture 153), so that all the strings are of different lengths, and each fibre will start to move in answer to a different note. The fact is, our ears can tell us of any note made up of waves that measure anywhere between 40 and 40,000 vibrations to a second. (Picture 154.) There is a fine little muscle tied to the handle of the hammer inside which stretches the strings just right all at the same time, as you see a man stretching his banjo or fiddle strings before playing. (Picture 155.) Of course a long string won't move as quickly to and fro as a short one. That is, each string always moves the same number of times in a second.

" Now we must have air both sides the delicate drum, or it would be pressed in flat by the weight of the air outside. So the other side of the drumhead is a fine little room, called the middle-ear. There is a door in the back wall of this room leading to a pipe the other end of which opens into the big air-chamber inside the back of the throat. If you shut your mouth and hold your nose, and swallow, you will hear air crinkle inside your ear against the inside of the drum. Big tonsils are apt to block up the inner end of



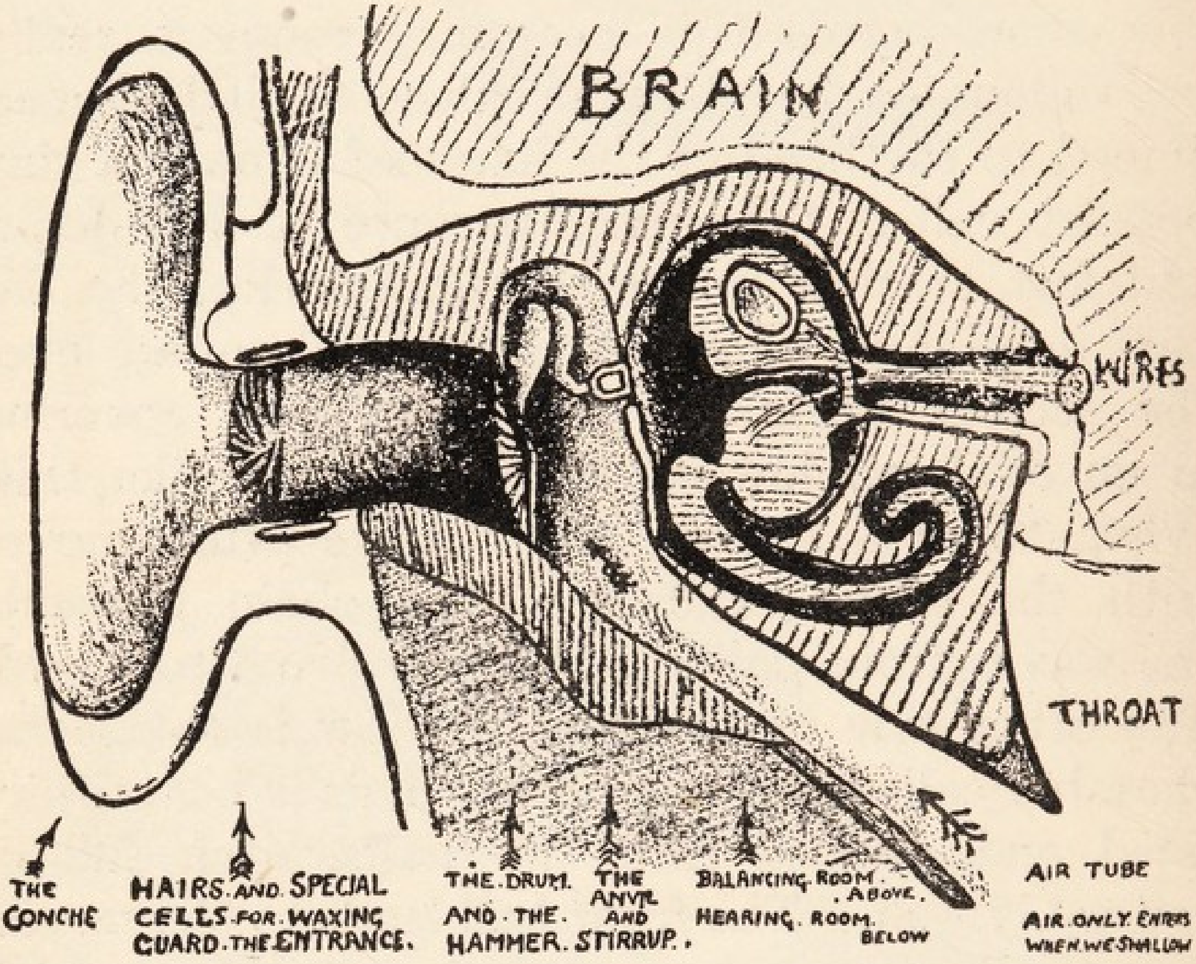
153. The handle is not quite in the middle.

155. The little muscle tunes all the strings at once.



154. The hearing room of the inner ear with from 40–40,000 strings

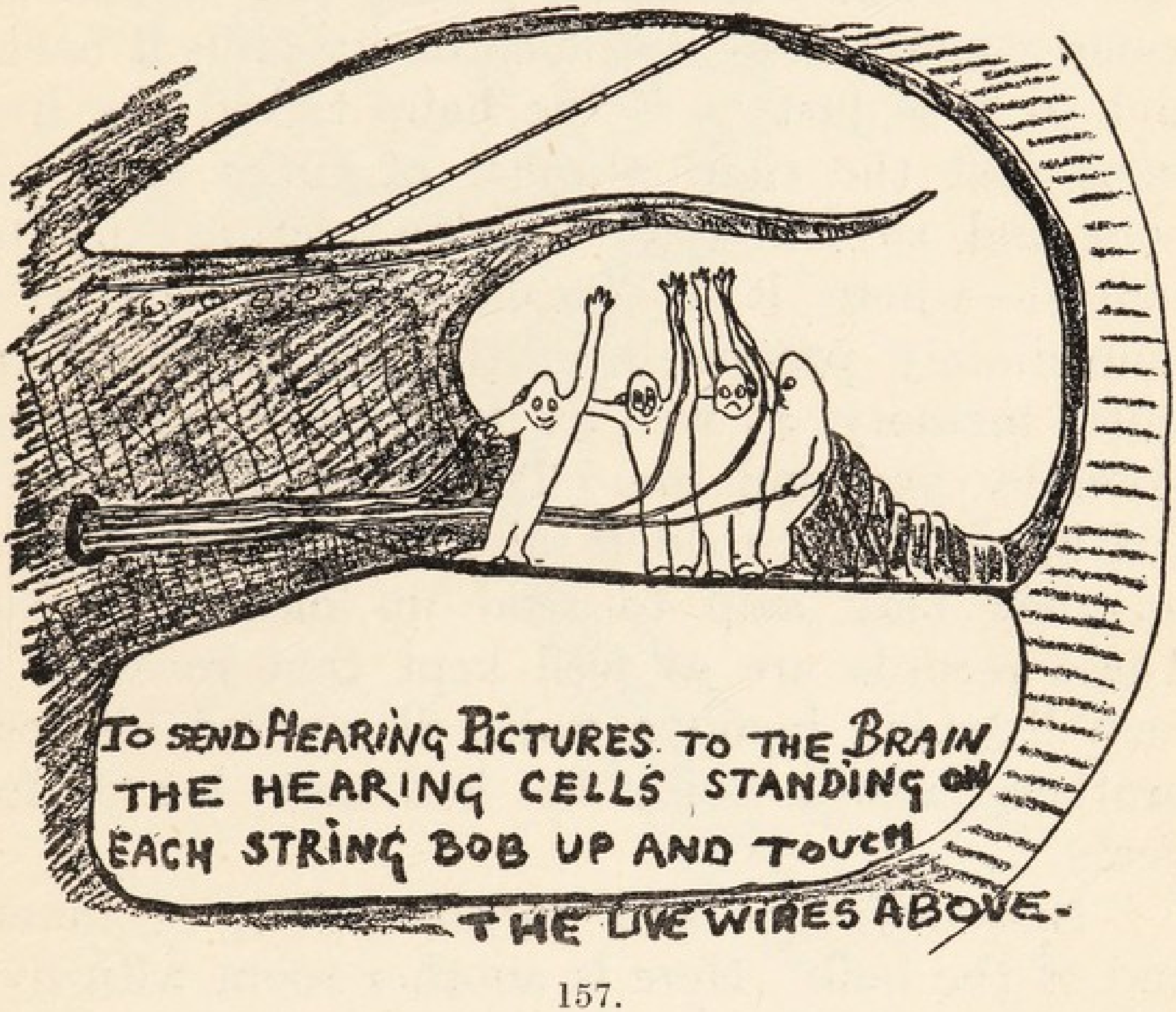
this pipe, or when you get a bad cold it gets blocked. Then you can hardly hear anything, because the drum gets pressed in and can't vibrate. The arrangement to carry the sound vibrations across this necessary room is really marvellous—a beautiful necklace of little bones. Joined to the head of the hammer bone is a tiny bonelet called the anvil, because of its shape, and fast to that is the stirrup bonelet, the flat part or plunger of which is fastened square over the second drum, a thin membrane covering in an oval window on the inside wall like this. When there is a noise the outside drum moves with the sound, and the little chain prevents the waves from pulling the inner drum too hard. The other side of the oval window is the secret chamber called the inner ear. This is beautifully lined and divided into two halls, each full of watery lymph. The front hall leads to the music-room. This is a long, tubular corridor which winds round and round an upright hollow pillar, getting smaller as it goes up, like the centrepiece of this conch-shell. (Picture 156.) There's a bone shelf half-way up the side of the corridor running round the central rod, and so many thousand of fibres are stretched from it to the outer wall that it makes a fine curtain, the strings getting shorter and shorter as you go up. Exactly as fiddle-strings or harp-strings get shorter to make higher and higher notes, so these do to receive and answer to higher and higher notes. A veil, only a single cell thick, covers over the outer part of this, as you see in the picture



156. Outer ear. Middle-ear. Inner ear.

—and in this queer passage formed beneath is the real hearing organ. This organ is made of a few special cells—and runs the whole way up the corridor from bottom to top. (Picture 157.)

" Inside the central column run thousands of wires to central—the whole is called the hearing nerve, exactly like the seeing nerve. One fibre runs out over the bony shelf to every single cell on the hearing organ. The oval window covered by the plunger of the stirrup is in the upper half of the corridor. There is a large round window in the lower half covered by an elastic membrane,

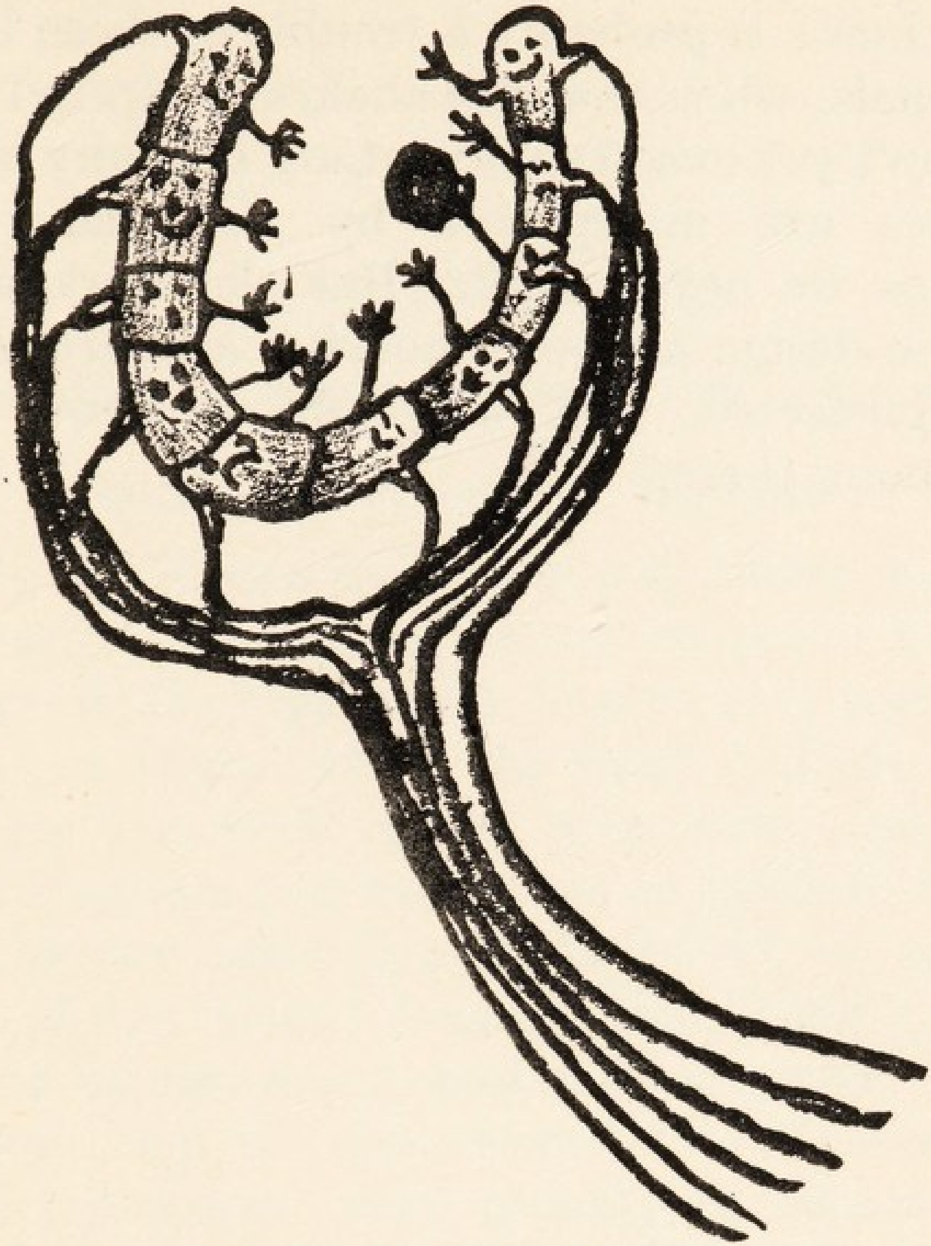


157.

exactly like the Eskimos use elastic seal-bowel skin to cover their windows, because they have no glass. In the hearing organ you see the rows of sensitive cells, each with fine hairs in it, and close over them is a special roof made up mostly of live wires, that is of nerves, to a cell mass, or ganglion, thousands of which are lodged on the circular shelf, and are local centres sending the messages through the hearing wires to central.

(Picture 157.) When the outside drum is moved by a sound-wave, the plunger of the stirrup presses the water in the top of the corridor down on the tips of the hairs, and that pushes out the elastic round window below—the elasticity pulls it back, and so it is just as if the hairs ticked the live wires just the right number of times for each note and so wired a 'hearing picture' up to central—where it is (exactly as in the eye) immediately preserved in the record chamber, called memory, as well as interpreted and acted upon by you and me. There are little specks floating in the corridors also, and when stirred up they may help to send up messages also. These records are so well kept that recently a man listening in on a radio discovered his lost brother, whose voice he had not heard for years.

"Now let's go back to the other, or inner, end of the hall. Here is another room with five doors, each leading into a big bony tube. Each is half a circle. So they are called semicircular canals. Here in this chamber, which is also filled with fluid, are again many small specks, and also a number of cells with hairs. The canals lie in the shapes of big bows at right angles to one another, so that one is down when the other is up, whichever way your head moves, and into them also the fluid goes. There is a row of wires that goes to this room also, but it does not come



158. Balancing is like playing ball. Whichever cell catches the ball sends a message to the brain.

from central-front office this time, but from the back or lower-brain office—and it is these canals which enable us to balance. (Picture 158.) When they move too much in certain ways, they get troubled, and we get giddy. Some think the specks lodge now on this side, now on that of the hairs as they move about, and the changing of the weight makes pictures in the lower brain—

sea-sickness is probably a trouble of these balancing canals, when the ship shakes us up too much. We don't yet exactly understand how any of these pictures are interpreted by the man inside. Perhaps we never shall. But the workmanship and the design are so wonderful, and are so carefully protected, that we ought to know all we can about them."

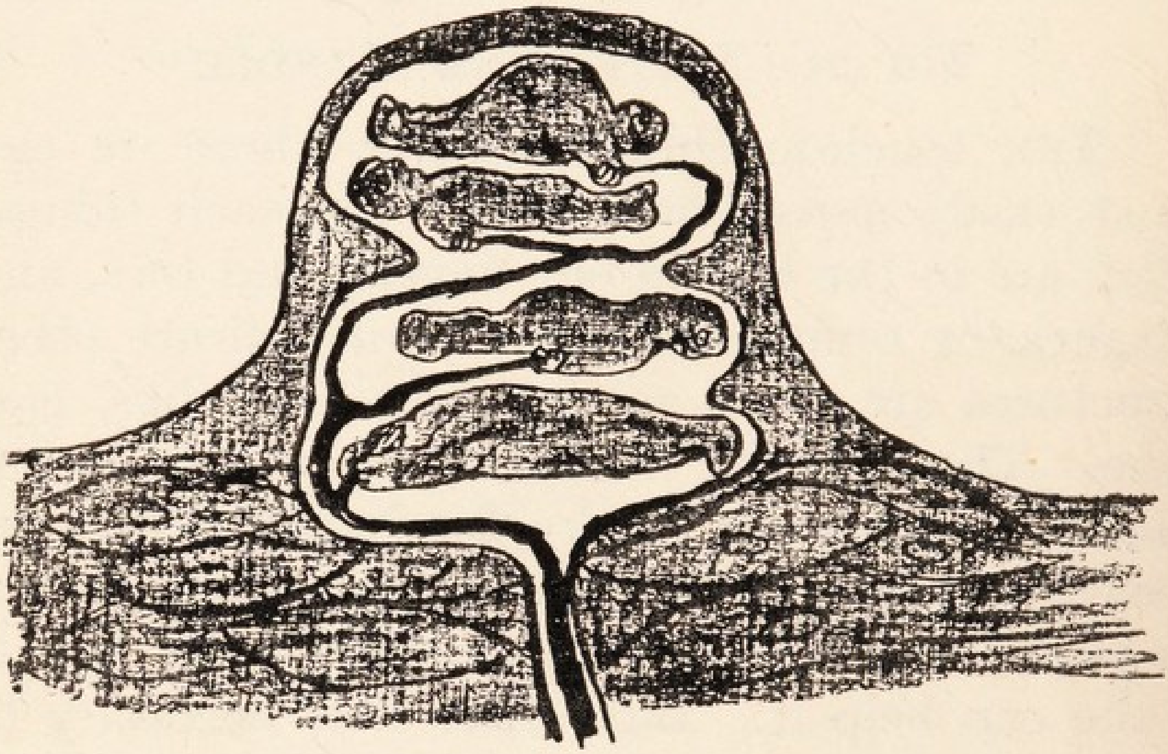
CHAPTER XIX

SENTINELS NUMBERS FOUR, FIVE, AND SIX

Touch—Taste—and Handle

"The touch-machines are put where we can most easily move them about to reach things. They are in the tips of our fingers, and toes, and tongues, or round where the most delicate other structures are, such as the eyes, nose, lips, ear-tube. They are not numerous or delicate in our backs, or our seats (lucky for boys), or on the crowns of our heads; because there they are not so useful or necessary, and nature never wastes if she can help it. But where it is necessary to get 'feel pictures' very quickly to central, the machines are immediately under the outside covering or skin, as in the balls of the finger-tips. We often say, 'Oh, that feels like something we have felt before,' and a blind man can tell instantly what a thing is if he has once felt it before. So you see, 'feel pictures' are stowed away in the memory bureau exactly like those of other controls. Here are some feel-cells—very simple but very delicate machines. You see, the end of the wire to central is spread out all through it—the touch-cell nerves often end in hairlike roots, to be still more sensitive. These tiny machines are like the tapper of a telegraph, only a thousand times more delicate—it is far the most delicate of all our 'senses.' Look at the different kinds in the picture shown below.

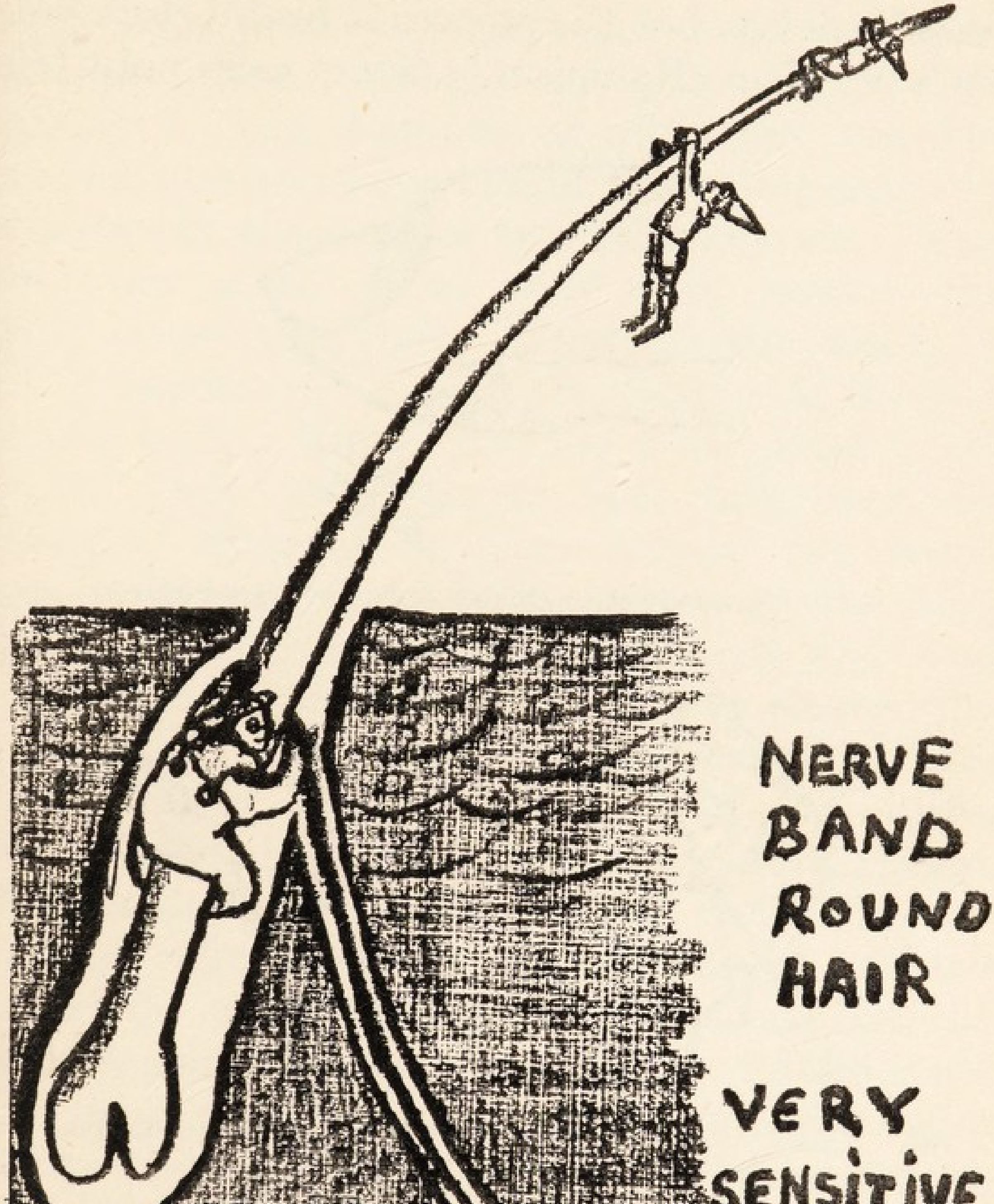
"In some places the touch-cells are so close



159. A very tender touch-machine.

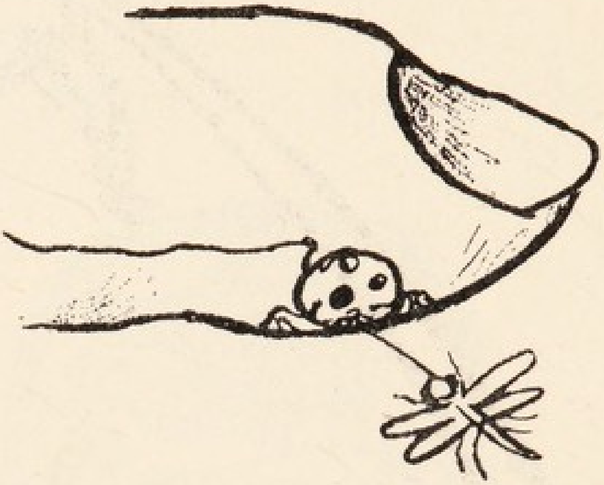
together the point of the finest needle couldn't go between them, as on the finger-tips, the lip, and the tip of the tongue. In other places, as on the calf or the back, they are farther apart. Round the hair roots they crowd together, so that hairs help us to feel—so a shaved skin is somewhat less sensitive.

"The tiniest tickle of the softest hair can make connections, and send a message to central. There is no real tapping and no noise—yet not



160.

only is the feel message sent off at once without a second's delay, but the answer is back before you can say 'Jack Robinson.' Some cells only tell



161. Thousands of touch-cells are on our finger-tips.

162. "Shut your eyes and see what happens if it touches your finger."

of hot things, and others only of cold things. Here is a hot needle. Shut your eyes and see what happens if it touches your finger. (Picture 162.)

"Though touch-machines are our first controls and are very simple, like all the others they have to be educated. Cross your two first fingers well over—shut your eyes tight—now roll this marble between them. What do you feel? Two marbles? Yes, because usually they are not crossed, and you have taught them that only two objects can touch those two sides at once. Now hold this stick. Shut your eyes, scratch the stick across this wall. What do you feel? A lot of partitions. Where are they? At the end of the stick. Right, but the stick doesn't feel them. Only your fingers feel, but they are 'taught' fingers. So your fingers can teach hopelessly blind eyes to see pictures by educating the machine back of the blind parts and deaf ears to hear, in the same way. Helen Keller, who was blind, deaf, and dumb, learned to see pictures, and to hear, and to talk and write. She educated her central cells by touching things. Her teacher poured water on her hand and said 'water,' when she was thirsty. Helen put her finger-tips on the teacher's throat and felt the voice strings vibrating out 'water.' So she made the same vibrations, and people brought her a drink. Now she puts her fingers on your throat, and you can talk away and she will hear you. So touch-cells make sort of gramophone disks in your record office for the eyes and touch and taste, as well as for the ears.

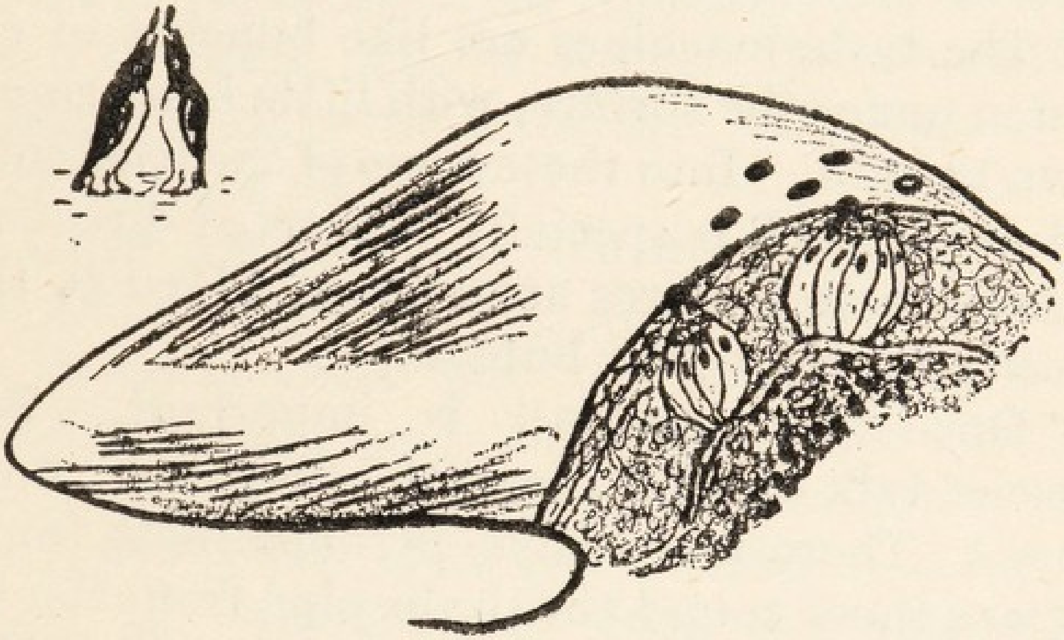
"Look at this book. All the letters are raised dots. Shut your eyes and draw your finger-tips over the letters. What do they say? I don't know. A blind man can read it for fun, and you could, too, only your cells want educating. On the other hand, we have learned not to feel some things. We don't feel our clothes touch us.

"Besides hot and cold and touch cells, there are also pain-cells. They are our S.O.S. signals.

163. A touch-machine for PAIN ONLY in the SKIN.

These don't notice ordinary touches. Only when the touch gets dangerous do they take any notice. Then they shout so loud the whole body feels, and takes notice, too. Touch your skin with this needle. Any pain? No. Now push harder, as if you were going to push it through the skin. (Picture 163.) Wow, it hurts! Well, that's a pain-cell yelling out: 'Danger here. Help!' It is the end of a little naked wire, in between the touch-cells, that is shouting. We should all be crippled or dead if it weren't for these little sentinels. Doctors can give you a dose which will deaden all the pain-cells without deadening the thought-cells. We often do that in Labrador, because then the patient can help us to operate on himself when we have no one else. There are no touch-cells in the clear front of your eye. It must never be touched. So there are pain-cells all over it.

"Our fifth control is called taste. The taste-



LIVING "TASTE BUDS" IN OUR TONGUES & HOLES OF OTHERS. THEY STAND AND SWALLOW LIKE PENGUINS.

164.

machines are placed naturally in the front end of the food canal; that is, on the back of the tongue and on the curtain over it called the soft palate. When you chew an orange small particles float into the nose through the front or back doors of the nose, and hit the smell hairs. We really smell many things we say we taste. If you hold your nose tight, or if your nose is badly blocked by a cold, you can scarcely taste at all, especially if your eyes are bad, or you are in the dark. The tongue alone can only tell sweet, bitter, acid, and salt. A big wine merchant bet the men who tasted the wines for buyers that they could not tell wines apart in the dark. He put glasses of port wine first and glasses of buttermilk between them in a dark room. They carried out the wines they liked best; but several were carrying buttermilk.

" The taste-machines are like bunches of cells, hidden under the surface, with little holes running down to each. Into these some of the food enters, and as each cell is specially connected direct with central, taste pictures are at once added to those already in the record bureau.

" One other sentinel is important. Some muscles talk direct to central—we call it ' muscle sense.' There are many—perhaps most important are those round the drain-pipe from the slop-basin and the catch-pool of the bowels. When these begin to fill up the muscles call out: ' Please empty the slops.' ' Please empty the slops.' The special reason for mentioning this control is because it is of the utmost importance for us to listen to it, because these door watch-men are like lots of other folks: if you don't listen to them in time, they just stop warning you at all. Like calling ' Wolf! Wolf! ' when there is none, and so at last the watchman gives no notice of dangers, and the people are killed. Anyone can see how dangerous it is to heap a lot of decaying poisonous slops in a delicate all-alive machine like our bowels. Yet people do it. They are too busy, or too lazy, or too shy, or too something. The result is that the bowel muscles get accustomed to retain large quantities of poison, and we call that being constipated. That's no reason to whip the poor bowel with so-called purgatives, or ' punishing ' medicines. No, make a habit of emptying slops regularly, and never be afraid to drink lots of water. Always answer quickly muscle-sense warnings. They are really important controls.

" Other muscle-sense machines are more delicate, as in our eyes. The muscles that move the two cameras must pull the lenses toward the object more and more as it gets nearer the eye. This muscle-sense gives us some information as to how far an object is away; whether it is big and far off, like the moon, or small and near, like a saucer. A one-eyed man can hardly tell at all the distance of an object.

" Now beyond all these machines for protecting the body we live in comes the greatest responsibility of all. It is the control that you and I can, if we will, use to make the whole body machine useful or harmful. Control it to use it for ourselves, or for others. I am sure you see how vastly important it is to have this control. Some young men say all they want is to be free. That means to use this marvellous machinery just as wild animal passions bid them, and that always makes you ten times over a slave, and at last destroys you. That freedom is the freedom of a wild ass, of the uncontrolled lawless fool. It invariably ends in wrecking the machine from which, often enough, there is no redemption till death lets us out of it. Meanwhile our best is then an inferior existence in an inferior body. True knighthood and real chivalry mean control and use of our machines for making a better world, and that alone makes life worth living.

"Control is always a hard matter. I can't control you boys, and only partly your body machines. No man can control another. Force only controls his body. So human laws based on force never can make either a perfect man or a perfect world. Perfect control must come from within, and is the result of your own will controlling your body through central, which can keep touch with our machines on one hand, and God's laws on the other. Obedience to them gives us the only perfect freedom—to serve God first, and your neighbour as yourself, is perfect living."

CHAPTER XX

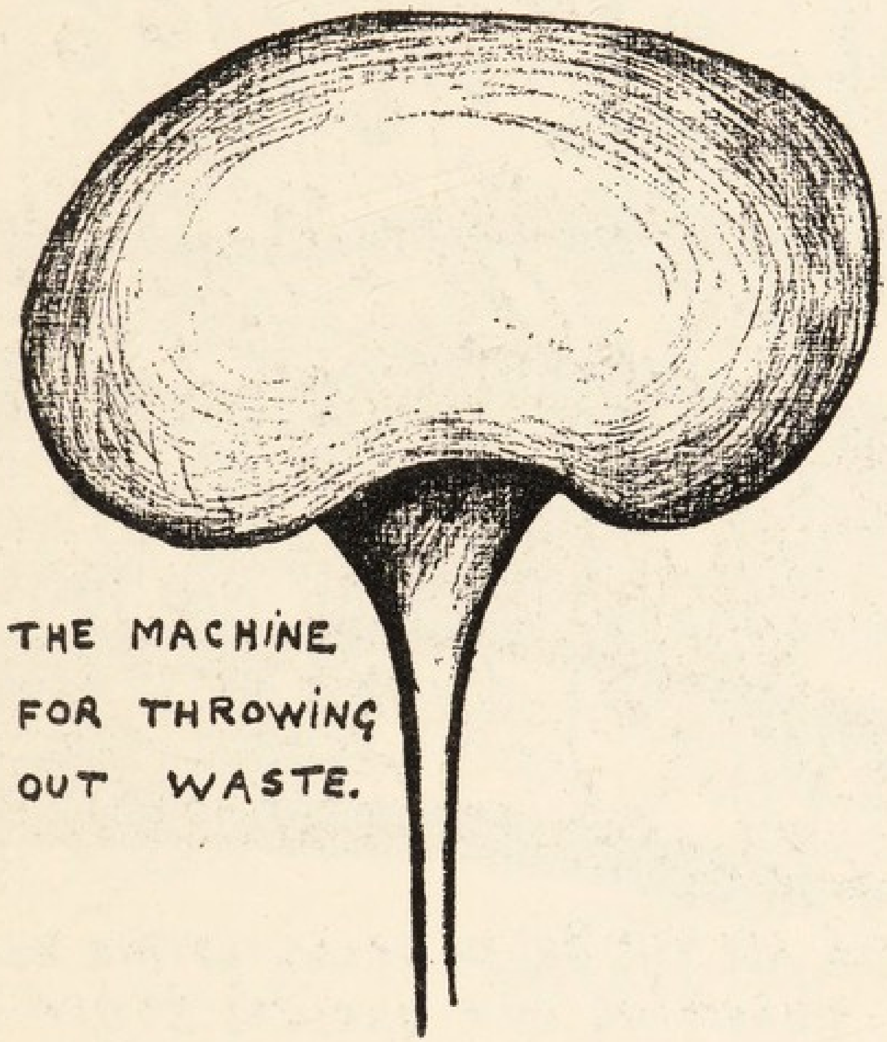
WASTE

"THERE is no waste—there is no death. All matter consists of electrons and they always are the same, so far as we know. But there are things in shapes in which our machines can't use them any more than a gasolene-engine can use heavy oil. We have spoken of how we get sick if all the remains of food that we swallow, and which is no longer of use to our bodies, is not passed on and out. We have spoken of what happens to all the soldiers, and police, and builders that all the while must keep on dying inside our big body machine. How the liver helps, and how the skin helps, and how the lungs help to throw out waste H's and C's and O's and N's in bundles as when two oxygens drag off one carbon in a bundle called carbonic acid, or when one oxygen drags off two hydrogens in a bundle called water, etc. All those machines can do a little more, when specially called on, as when we perspire or when we pant. But you must not forget that in these most wonderful machines that make up our body, every single cell is alive. It eats and drinks just as we do, and so every one of them, exactly like us, must also get rid of H's and O's and C's and N's all the while, and that right inside each part of each machine everywhere.

"Now we possess also two simply marvellous machines to pick out and pass all this on out of the body. The only machine more marvellous is the thinking machine, and I am sure you will say so. If these machines are destroyed, the whole body dies at once from plain garbage poisons, or toxins. Alcohol hurts these machines terribly. I have seen many people die young just because they had poisoned these machines with drinking alcohol. Eating too much candy also hurts them—so don't do it.

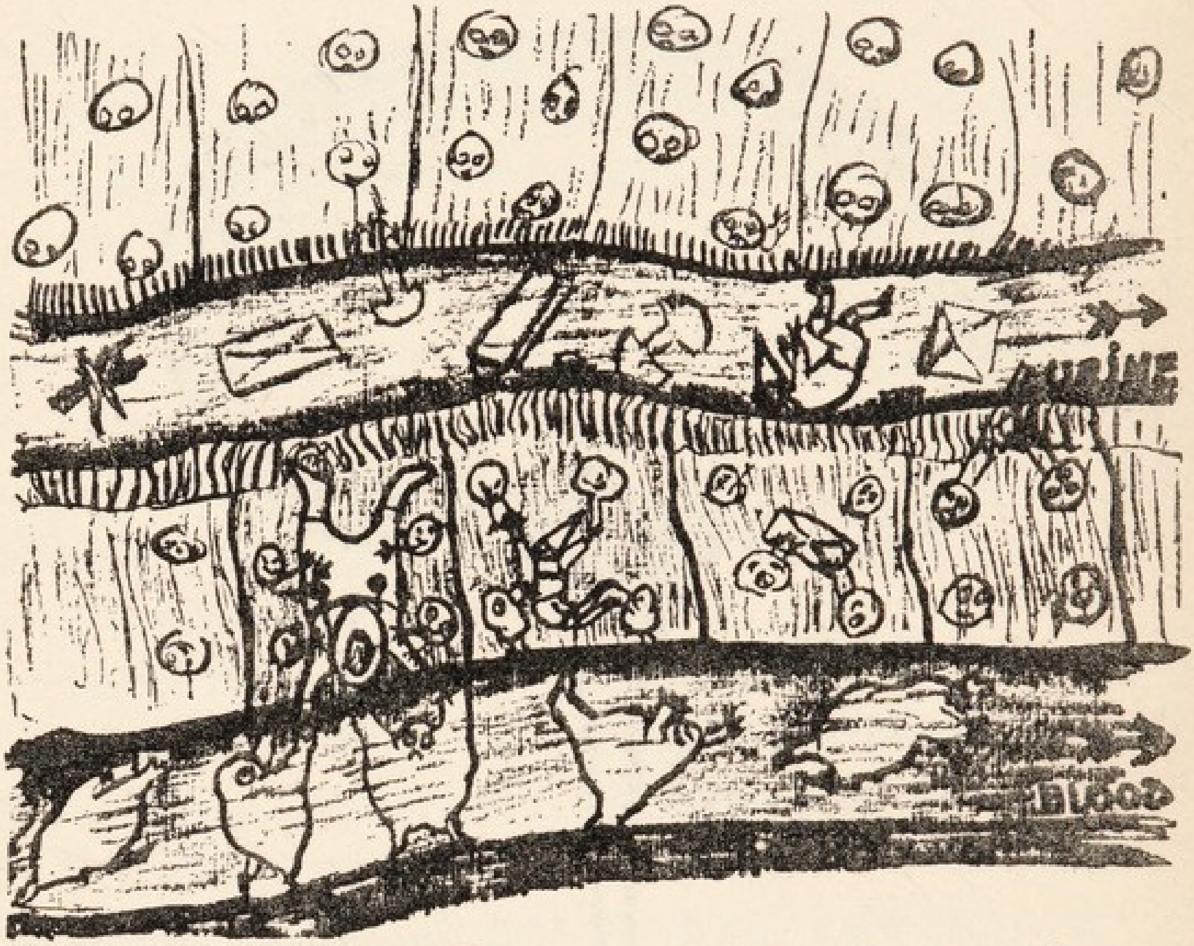
"These machines are so important, they are kept in the safest part of the body, away up under the ribs, close to the spine, on elastic shelves, well tied up, and covered all over with great soft pads of warm fat. Central knows well how important they are, and if a doctor has to take one out because it is diseased or killed by its enemies, as those pirates of King Tuberculosis sometimes succeed in doing, then central sets to work at once, and makes the other machine twice as large, so as to do the work for both. These two machines we call 'Kidneys.' You know the shape of them—they look like this. (Picture 165.) They are really living filters, specially to keep the blood in the pipes always pure and normal. They contain thousands of tiny pipes through which dirty blood is brought to them to clean (Picture

166); the feed-pipes to be longer and give even more surface being rolled up in little balls like string. These look like apples on a tree. Round



165.

each is a small sac. (Picture 167.) Stationed all around them are very learned, specially trained cells, which filter off an average of two pints of water a day, in a very clever way. The feed-pipes into the balls are larger than the return pipes, so there is always a pressure in them. Also, the wall cells of the sac are very thin —so first of all the water leaks through. Some things that the blood must have the right amount of, like salt, however, also break through. This water gathering from the pipes drops into a

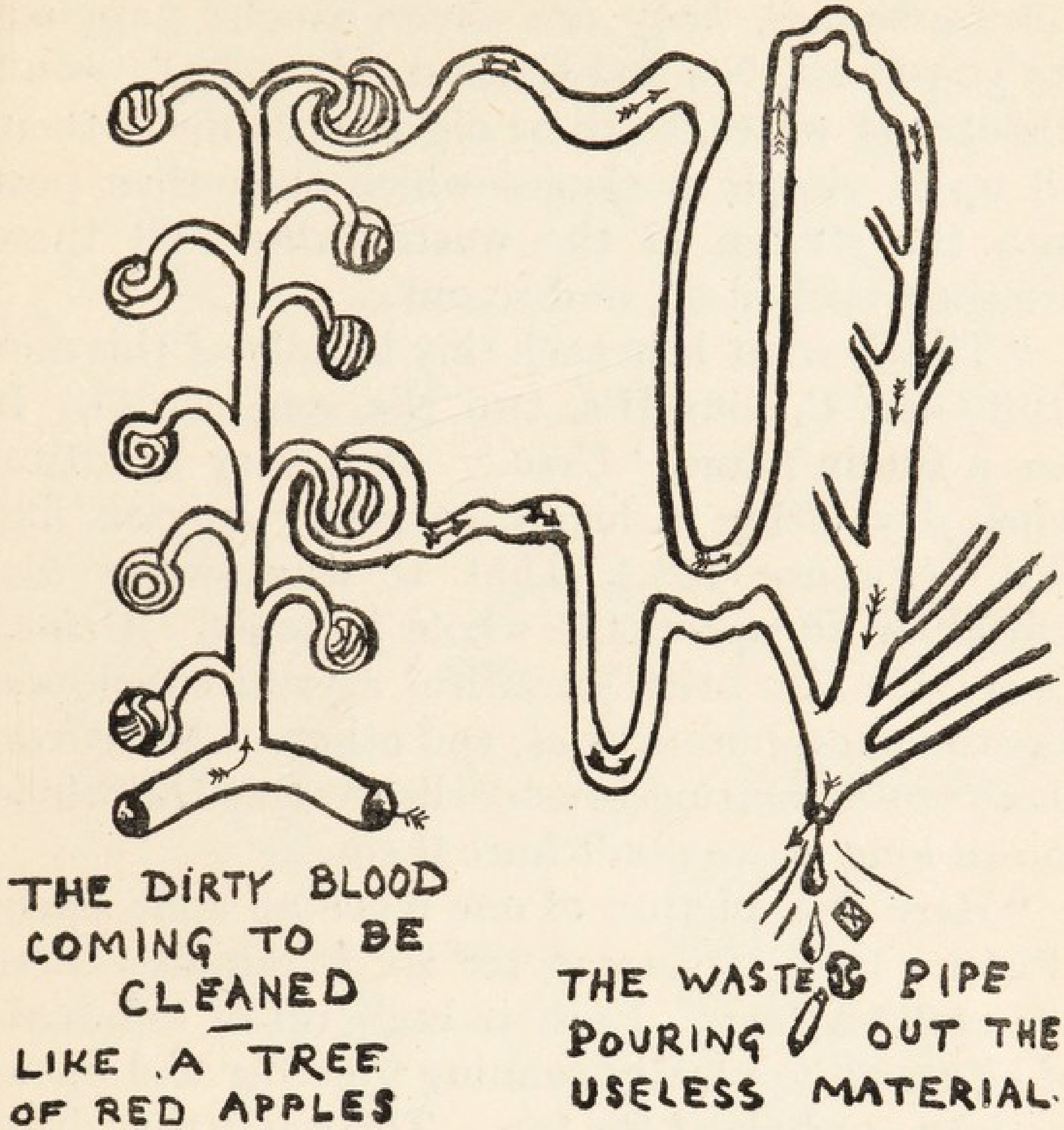


THESE ARE THE BRUSH CELLS OF THE BLIND TUBE. THROWING OUT USELESS STUFF AND GIVING. BACK. TO. THE. BLOOD. WHAT. IT. CALLS. FOR

166.

blind tube like a 'U.' There are some of the cleverest cells in the body here—surrounding all the walls. There are none like them elsewhere. These watchmen have heads like brushes, and are very keen detectives and very clever.

"Thus, they hear the blood-cells calling out, 'We want more salt'—so they pick out all the



WHAT HAPPENS IN A PYRAMID.

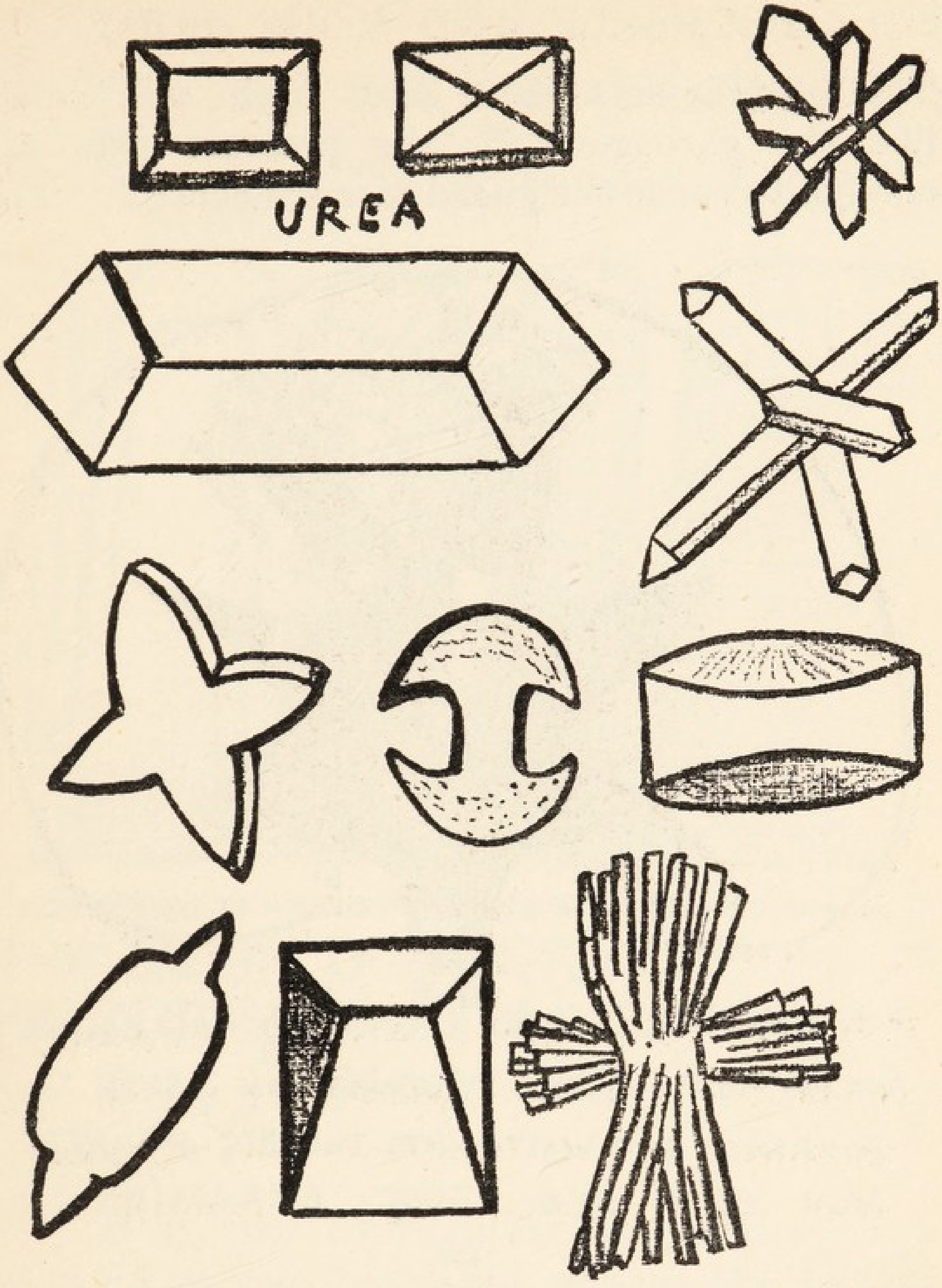
167.

salt that comes past and return it to the blood. Or, when the blood-cells call out, ‘We want water,’ they swallow that and pass it back into the blood. On the other hand, if the blood-cells shout, ‘We have too much sugar or too many N’s,’ they can pick it out through their other end and pass it into the waste tube. (Picture 167.)

Like a weasel, they are never caught napping. As you know, N's and C's and H's and O's won't dissolve in water, so these clever cells make them all up in simple packages which they then post into the stream in the waste tubes and these are then washed on, and so out.

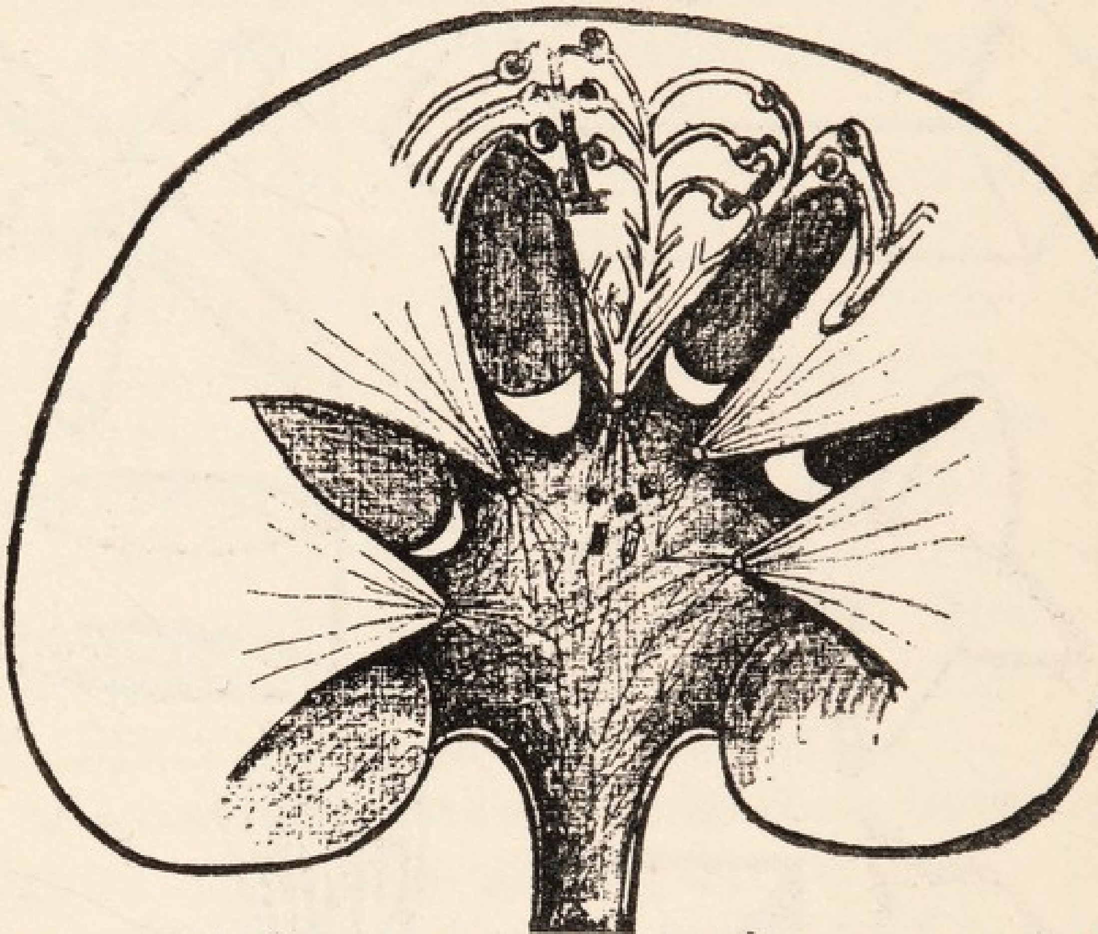
"This is what is in each tiny bundle of this new stuff—one C, four H's, two N's, and one O. It has a funny name, '*Urea.*' It is very beautiful when dry, being in lovely sparkling crystals like this. (Picture 168.) That is why, when dissolved up in water, the whole is called '*Urine.*' There are also other beautiful crystal envelopes, like the phosphorous ones, and others. Moreover, these most amazing brush cells oversee the whole job so long as we don't hurt them.

"Here is a picture of one machine split open. (Picture 169.) You can see six pyramids—there are really fifteen. Each is built up of hundreds of pipes, all gradually running together and opening into one hole at the top. The water that drips from there is now caught in the large funnel and passed into a long tube, which is really a pump, pumping the water on into a big bladder below, through a fine valve in its wall. The outlet door of this is guarded exactly as the garbage cesspool by a muscle round the door. The bladder lies in the bone basin on the top of the arch made by the leg bones. It is put close alongside the cesspool, as both are for a similar purpose, and the wires to and from central can then run up together.



THESE ARE THE BEAUTIFULENVELOPES — IN WHICH THE WASTE SUBSTANCES ARE CARRIED OUT IN THE WATER.

This bladder acts like a catch basin, till, exactly like the garbage well, the pressure gets high enough to cause the guard to warn central. Then

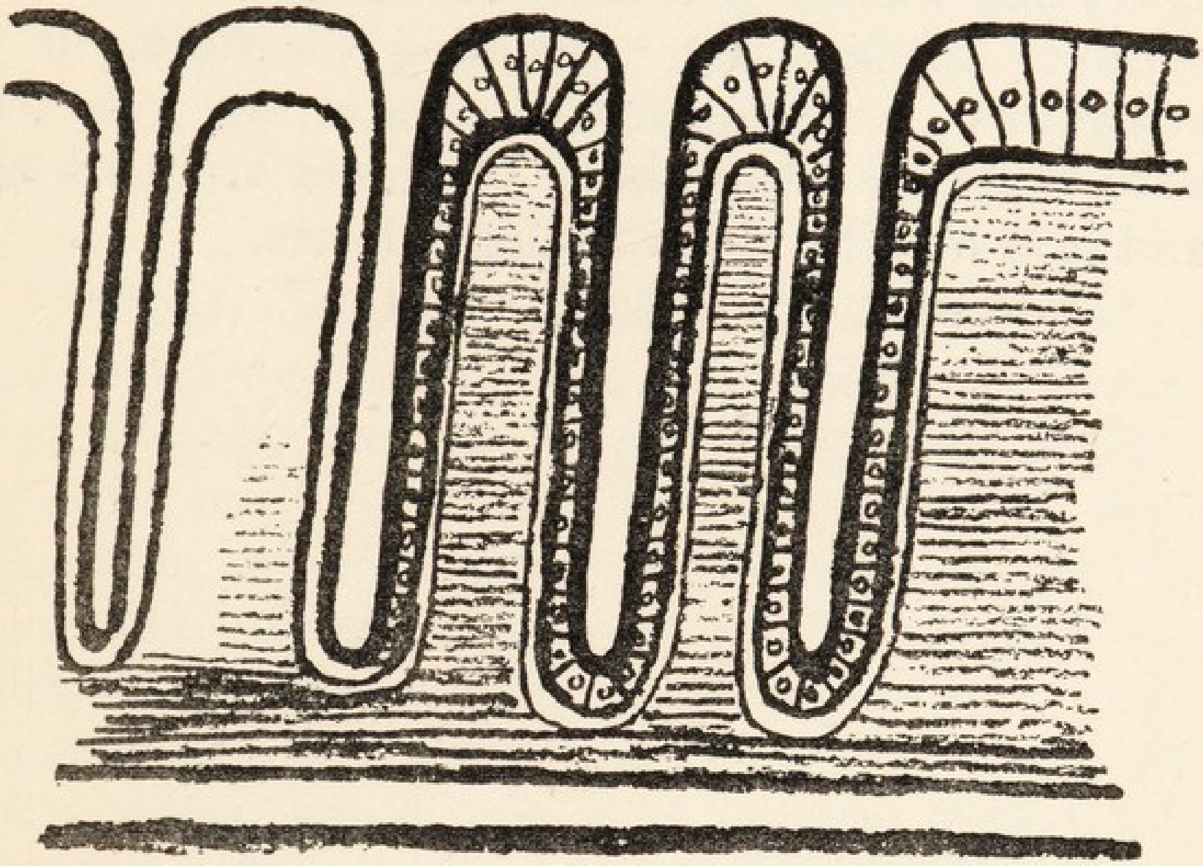


THE AMAZING BLOOD CLEANING MACHINE
AND THE MOST VALUABLE PYRAMIDS ON EARTH.
POURING OUT WASTE INTO THE BIG FUNNEL.
YOU CAN SEE FIVE PYRAMIDS.

169.

central again orders the lower guards of the muscle around the tube, that leads out of the lower part, to 'let go,' and then the muscles around the sides of the bladder 'squeeze out the water.' This, just like emptying the garbage, is partly under our will control; so that we can have time to arrange to empty it as conveniently as we like.

But let us look for one moment at the filter



THE BEAUTIFUL GREASE FACTORIES THAT LINE MOST OF THE INSIDE TUBES.

170.

part. It is like overhauling the engine of a motor. You see these cells around the ball of pipes. You also see them around the 'U' tube. These are the wise old fellows I spoke of. They can do more than central can, or you and I and central together, and if they don't do their work, the machine is useless, so never send a lot of alcohol along in your pipes to poison these poor things, for they are our most faithful friends. Amongst the waste they pick out are the old remains of dead red soldiers that come along in bile salts, which, of course, turns the clear water yellow. In fact, by examining carefully, in a laboratory, a person's waste water, we can tell very well how all the body machines are working and how healthy the working cells are.

"Here ends this difficult chapter."

CHAPTER XXI

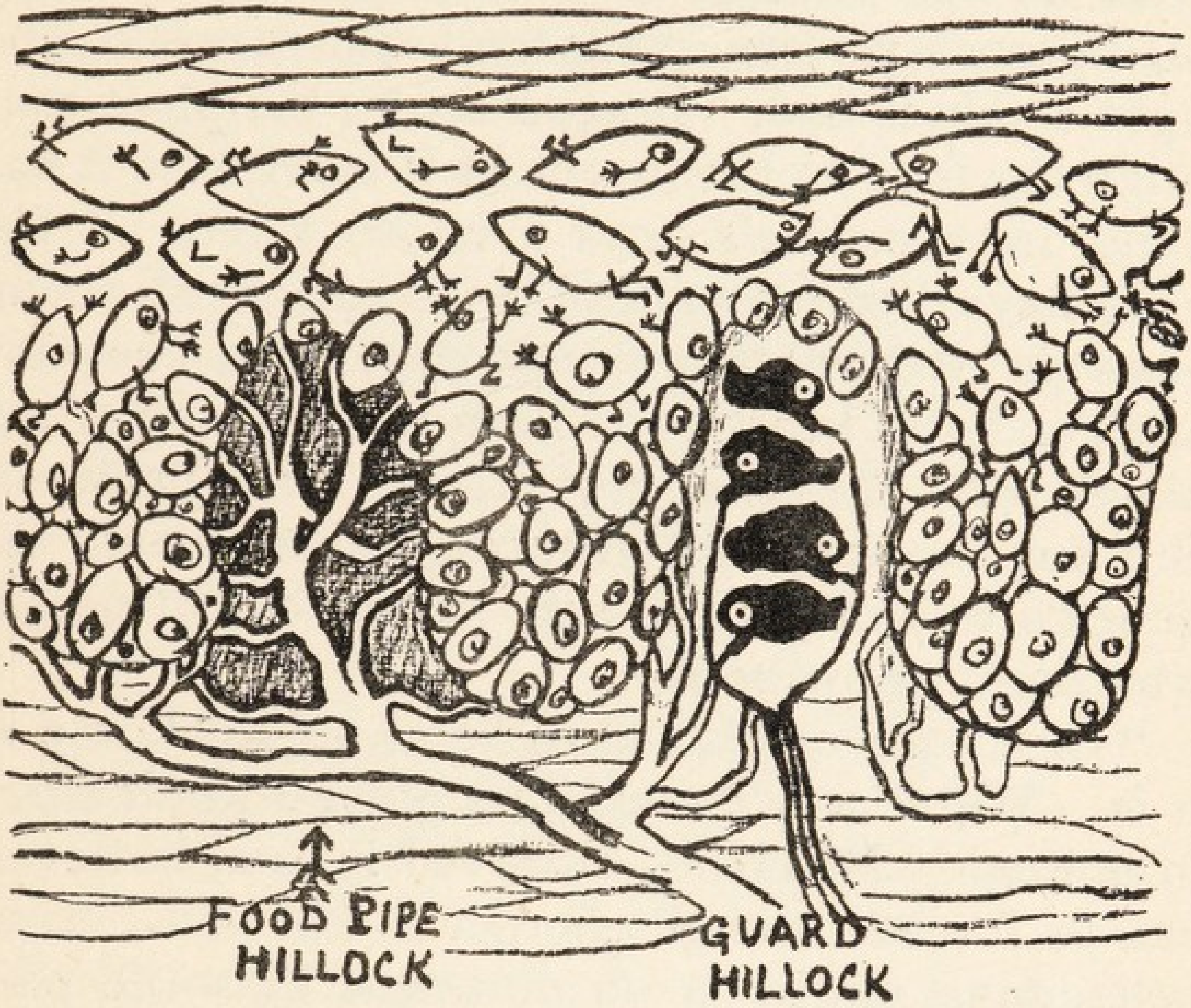
THE OVERALLS

"When all the machines are packed away in the framework we must have a covering, and it must be suitable for our own work. Thus a fish's outside must be smooth and greasy, to oil along through water—a rhinoceros's must be heavily armoured for protection—a bird's very light and yet warm, so feathers are best—a polar bear's very tough and heavy, and so it is covered with fur. Ours should first of all be very elastic, very strong, and very sensitive to warn all the machines inside of any danger. We can make clothes and armour for ourselves if we want them, and therefore we needn't worry about growing fur or feathers, or a crocodile's leather hide, or a toad's poison glands, which we couldn't put on and off when we want. No. Man lives by his wits, and therefore the main thing is to have a good stout covering that will carry nicely and safely a lot of sensitive instruments for signalling to his wits. It must be fairly thick. I have seen a man's skin tanned, and it made quite useful leather. It is continuous with the linings inside the mouth, nose, lungs, bowels, bladder, ears, and all inside tubes; but is changed in construction specially to suit each part.

"Don't you think our skins are the most beautiful in the world? Look at the softness, at the colours, at the elasticity, and how every particle is alive. Our outdoor skin gloves wear into holes and we throw them away. But busy little fellows are all the time repairing our own outside covering; in fact, it is itself alive. So clever are these workers that they always repair it exactly as it was—never one fraction of a change, unless the whole has been destroyed. So wonderful is their work that even the covering of the tips of our fingers, that we are wearing out every day, remains the same all our lives. A criminal can be identified by detectives by wax impressions of his finger-tips taken twenty years before—even though his face is so changed his own mother wouldn't know him.

"You hear people talk sometimes of others having two skins. That is not so. The truth is, that on the top surface the cells die on purpose to protect the others, and then, of course, they wear out and fall off, and more go on doing the same. It is like laying down your life for your friends. (Picture 171.)

"Beneath them comes the layer we will call the 'volunteers.' They are arranging themselves to die in long ranks, lying sideways so as to cover more surface. The busy crowd out of which they come, that lives around and among a lot of hillocks, is nicely moulded in mounds of tough fibres, and these are burrowed through and



SECTION OF. SKIN. Showing NURSERIES of REPAIRERS. VOLUNTEERS. ETC. ALSO FIBROUS INSIDE. and HORNY OUT-SIDE

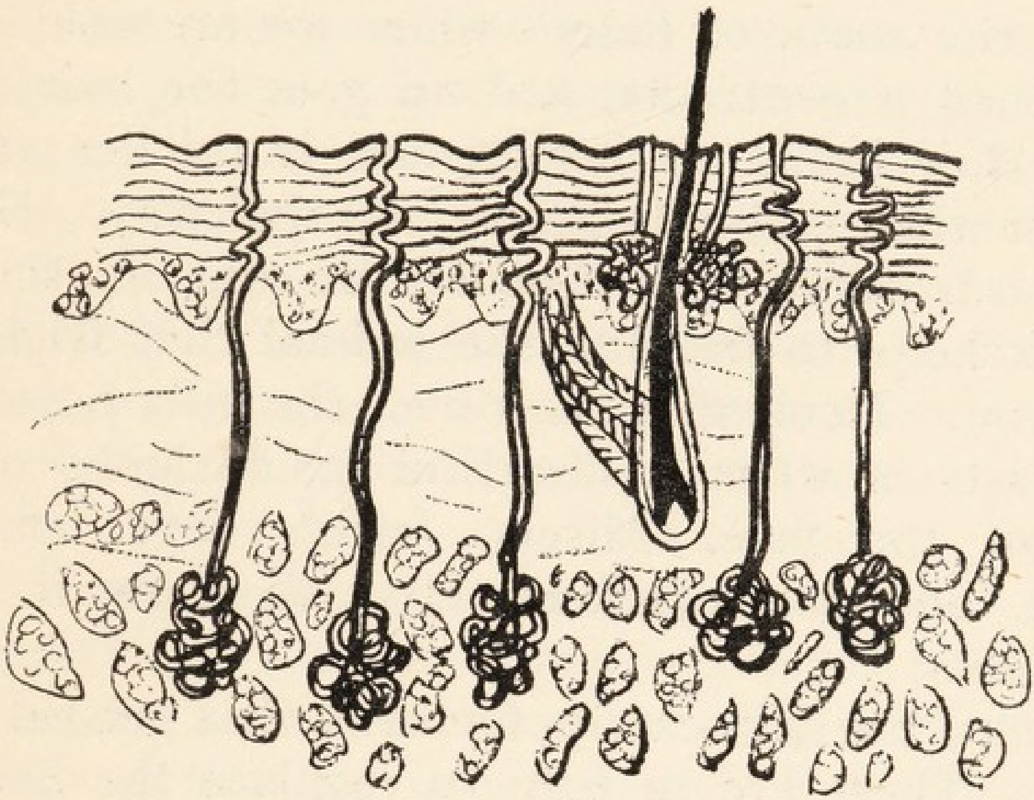
171.

through with food pipes to feed the crowds. In some are hidden guardsmen, like the touch-machines, and cold and heat and pain detectors, who are there to protect the whole body.

"Our covering is fairly loose—held down only by loose bands. But it is not quite so loose as Towser's, who has to be able to shake his skin after he has been in the water. We don't need to, because we can make and use towels. Too tight a skin is bad. It squeezes up the pipes that bring the food to the machines it carries, as it has done in someone's head I know, where all the hairs have died for want of blood to nourish them. Massage and rubbing every day, with sunshine and good stiff brushes, to keep the skin full of red blood, are far the best things for baldness. Burning the skin with irritating lotions is only the quack's way of getting easy money out of people who don't know better.

"Of course our skin must be water-tight, and so it is. Water won't soak through and won't carry in poisons. Medicines dissolved in fats, however, can be forced through enough to kill you. Thus belladonna mixed in an ointment kills the pain and itch of fly bites. But some of it also sinks in and paralyzes the eye muscles, and makes the great large black pupils that actresses love so much to have.

"Our skin, besides being our armour, has to help greatly to keep the whole body machine always at the same temperature. To do that it has the cleverest dodges you ever saw. First of all, it has a great many little factories for making wax. These glands are always putting out a little wax on the skin to keep the surface supple, especially in hot weather. But suppose it suddenly gets very cold—well, there is a little muscle round the gland that immediately squeezes out some extra wax, other muscles that bunch the skin up together and make it thicker, others that squeeze



PIECE OF SKIN SHOWING FOUNTAINS · WAX GLANDS · HAIR.

172.

the hot pipes in the surface and so save heat being lost. The skin has become, therefore, white and thick and waxy. We call it 'goose' skin. But it saves a whole heap of heat. These little factories are most numerous on our face, because it is always exposed. If their openings get choked, they make spots on our skin, and we steam the part in hot water and so help to move the block along.

"Then, there is the hair, which is part of the skin.

We don't need it for warmth, like a bear or a beaver, because we can make clothes and fires. But it does help to make us beautiful. What would a young girl or mother look like if they were as bald as a coot? There is a funny little muscle round the roots of hairs—when we are cold or frightened it contracts, and up goes the hair on end. Hair holds air better, and is thicker and warmer when it stands straight up that way. See how birds ruffle their feathers in cold weather. Also, it helps to frighten the animal that frightened you. Remember, however, the only beauty that lasts is when a beautiful inside looks out through the face. Misers, selfish boys, cruel people, cowards, drinkers, etc., all show it in their faces.

"Next, the skin carries factories that get rid of water. These are to help to regulate the heat. If you fill a flat basin with water and stand it outside on thick straw on a warm night, in India, the evaporation is so rapid and takes so much heat to evaporate it that ice will form in the bowl. Water evaporates all the time all over our surface. But there are two and one-half millions of little reserve fountains all over our body ready to turn on to wet the skin and cool it down, as soon as its heat rises even half a degree. Sit quite still in a very hot room, and as soon as ever your whole machine is one-half of one degree hotter than usual, the fountains begin to play, and little streams run down all over your body and start evaporating, and we call it sweating. Of course, it is just the same thing if you work or play very hard. You have then to burn up a heap of fuel in all the muscle machines, and the whole body would soon be in a 'fever,' but the fountains all start going and the whole machine keeps just the same heat. Each person uses up about two pints of water a day in this way, but in a hard football match two pints are lost in an hour. So with the fuel burned up and other waste one of my friends lost twelve pounds of weight in one short hour and a half, playing for Harvard against Berkeley in California. The fountains are practically all managed by local keepers. Put one arm under a glass case in the sun and it alone will sweat; the rest of the body being quite dry. If you send a message along the main wire of someone's leg that has just been cut off it will actually obey and start sweating. You do this by touching the cut end of the nerve.

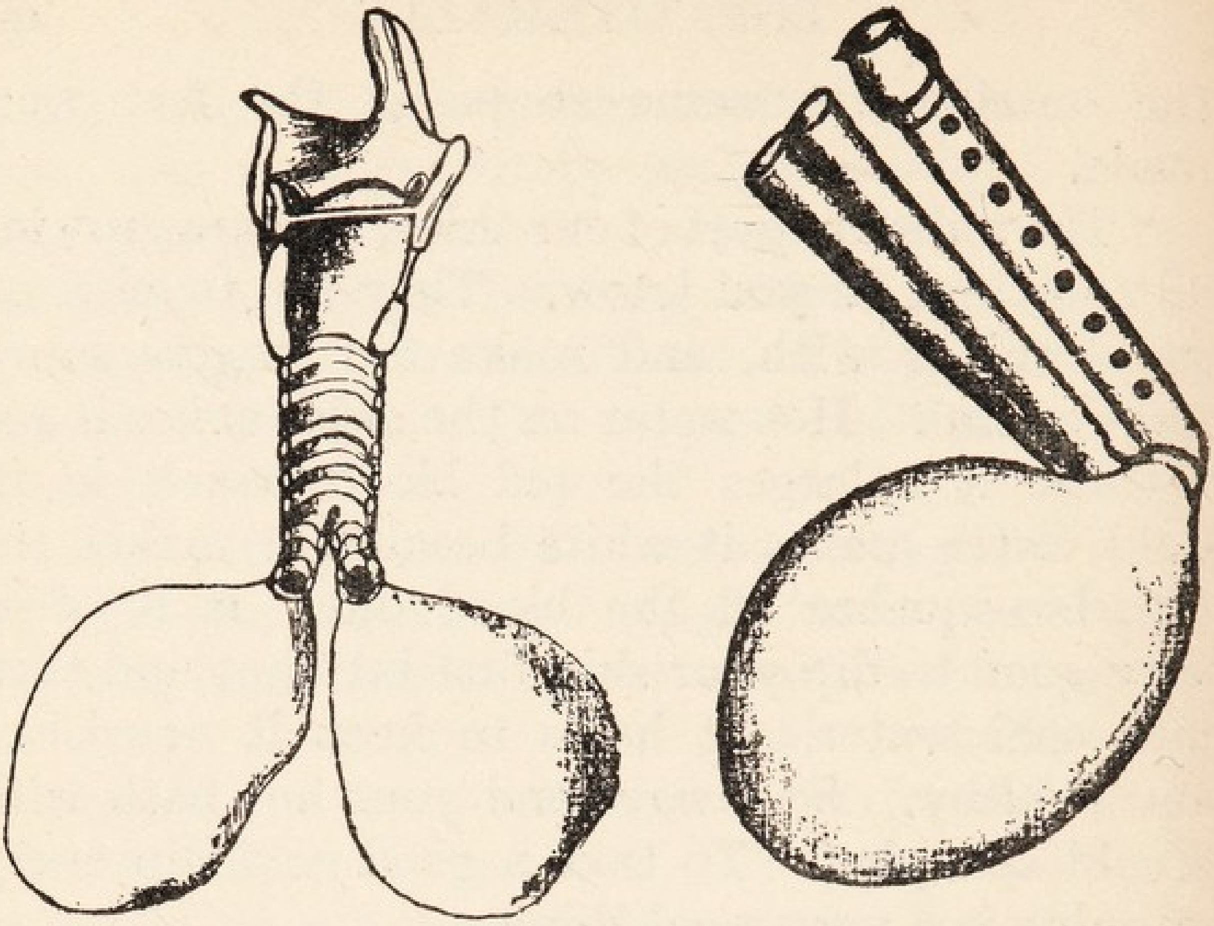
"There is one important thing to remember here. Clothes don't ever make us warm. They only keep in the heat we make. In Labrador we make our clothes of close-woven canvas with strings in the edges, so that when pulled tight there isn't one single leak of heat anywhere. By opening and closing the edges you can keep warm or cool as you like. A marble statue won't perspire if you put all the fur coats ever made on it.

"In a still, hot lecture-room full of people the water evaporates and makes a real cloud, and then all the hot breath they breathe out gets held down and they get sleepy and headachy. Start a fan going, blow away the cloud, stir up the air, and they all begin listening attentively to the lectures again. Practically no carbons come off through our skins. The oxygens can't pull them through.

"We have spoken of the many arrangements in the skin for signalling 'danger.' In the world of live cells that make up this marvellous covering are many detectives. The sensitive hairs and touch-cells and pain-cells and cold-cells and heat-cells are among the number. These are arranged especially on all the vantage posts, like the lips at the entrance to the food canal, or the fingers that hit up against everything and can feel everywhere, and especially the tickly cells in the arm-pits where the big vessels lie. As I told you, the outside cells of the skin are really tiles or scales filled with horny stuff. Like the great horns of a deer that are made new each year, so are our outermost scales growing anew all the while. That is how our skins mend their own holes, when we wear out any part, like we do our socks. In fact, sometimes they get so eager to cover over and protect some tender part, that they make too many scales, and great hard heaps get piled up and hurt the tender cells beneath, and we call them corns. So never wear horrid boots with high heels or with pointed toes. Wear shoes straight on the inside, and on the outside, the same shape as the feet were made.

"The nails are part of our skins, and are growing all the time, as you know. They are to pick up small things with, and make our fingers much more useful. Hot water on the skin makes it red because it enlarges the red blood-vessels in it. Cold water makes it white because it makes the muscles squeeze all the blood out. It is often very good to dip your skin first into hot and then into cold water. It helps to keep it nourished and healthy. So always end your hot bath with a cold sponging. To take a good cold dip every morning is a very good thing.

"Enough said—off you go and wash your skins before bed."



173. Two wind-instruments. Man and bagpipes.

CHAPTER XXII

THE TALKING-MACHINE

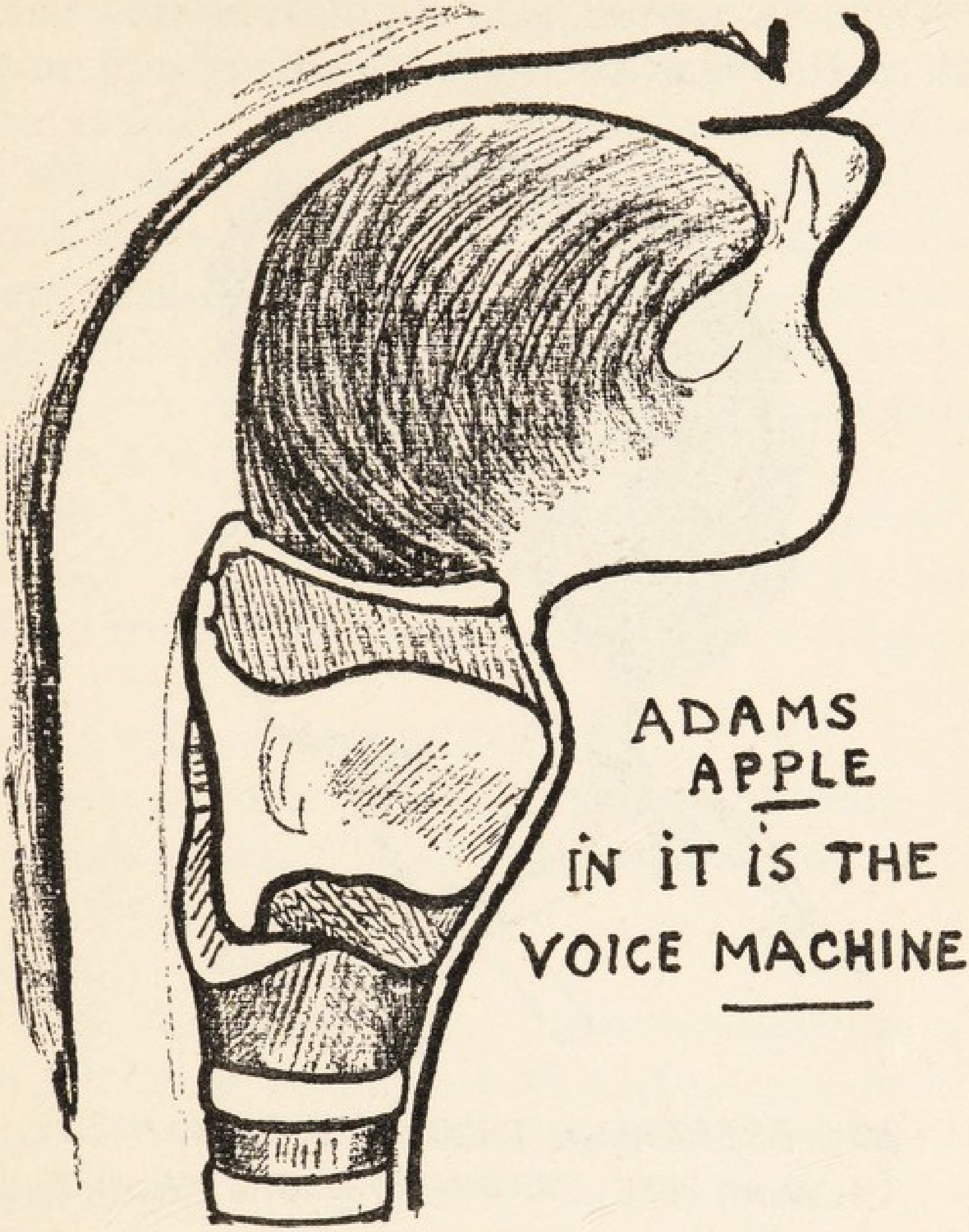
"MAN is a talking-machine. At least, he talks more than any other animal, even if he doesn't sing better than a nightingale."

"But how does he do it, father?"

"Oh, he is a wind-instrument. Like an organ pipe, he uses his air-pump to blow wind through a hole between two reeds in his throat." (Picture 173.)

"Oh, father!"

"It's true. Two reeds or strings are stretched from front to back in the wind-pipe, as it passes



174.

through ‘ Adam’s apple.’ That is the lump you feel in your neck beneath your chin. If you take an old air-tube after a man has gone and left it, and blow wind through it it makes a fine noise; or if I take this instrument and look down a man’s throat through it I can watch his voice strings moving as he sings. (Picture 174.)

"When a person gets diphtheria this narrow part of the wind-tube gets filled up, and several

BOY BREATHING THROUGH TUBE PLACED IN WIND PIPE BELOW SPEAKING MACHINE

175.

times I have had to make a hole lower down in the pipe and put in a tube, or the person would have suffocated. Then he couldn't talk at all, because the wind escaped below the strings. (Picture 175.)

"The lungs are our bellows, and our throat and chest and belly muscles all help us to blow harder or softer as we like. If the strings stay the same length, the harder we blow the higher the pitch of the sound. You can't make any noise without you blow hard enough to hold up the weight of a column of water ten inches in height, and to make a very high note you must blow four times as hard. Most people can only make about sixteen notes, and the limit is about twenty-four." (Picture 176.)

"But how do you make the different notes?"

"That is the marvellous thing about these reeds. We can make them shorter or longer at will."

"But what does that do?"

"Look at this fiddle. Now twang this long string and listen. That is the same note as this one on the piano, isn't it?"

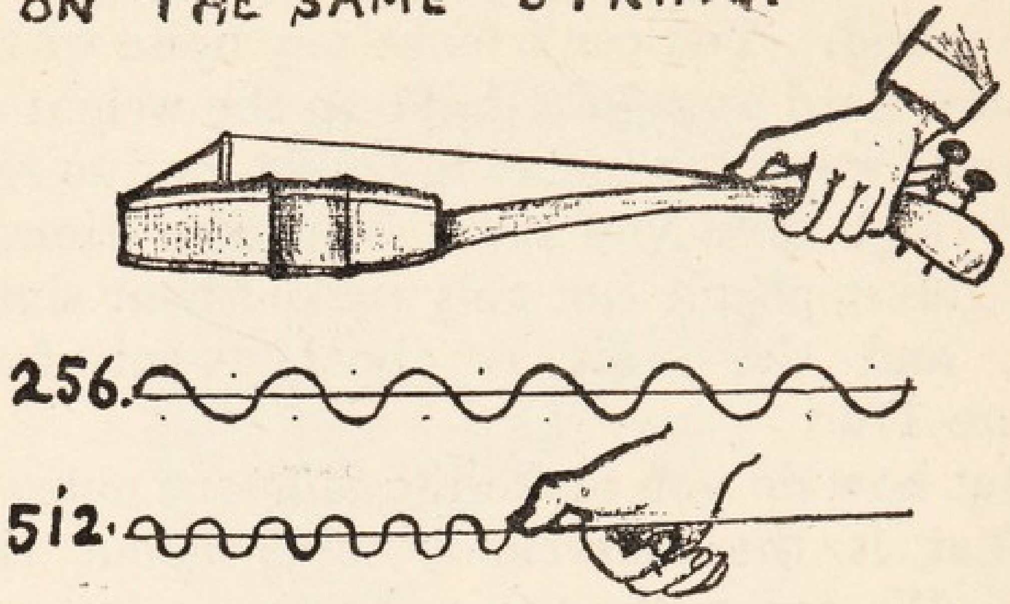
"Yes."

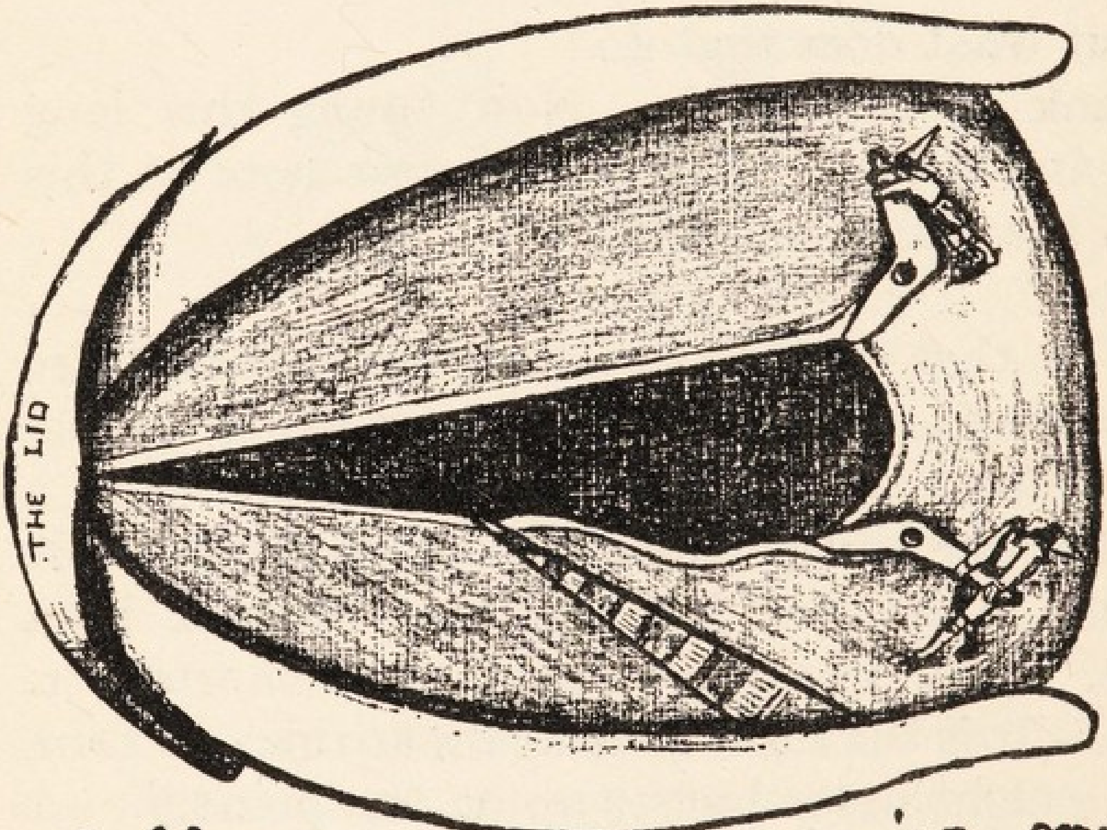
"Well, that is called C. It means that the wire I am hitting in the piano with a hammer is making as many up and down movements or waves in a second as the string which you are twanging. It happens to be two hundred and fifty-six in a second. Now twang it again as I shorten it. Listen. It is the same note again as this one I am striking eight notes higher up on the piano."

"Yes, father."

"Well, that is the octave and means that the wire and string are now each making five hundred and twelve waves a second, or just twice as many as before. That is all there is to it—isn't it

HOW DIFFERENT NOTES ARE MADE ON THE SAME STRING.





A. MUSCLE STOPPING A VOICE STRING.

176.

easy? But don't forget that all these waves do is to hit the air particles and set them moving, and so the particles hit the strings in your ear and make a hearing picture in your brain, which, of course, central interprets. These particles travel rather slowly, only about four hundred yards a second, so we use electricity when we want to talk far away. This sends them nearer two hundred thousand miles a second. These waves then go on and on and on until they hit you, and, now that we have wireless and radio, we know that if you make waves in Boston they hit us in Labrador, because we can hear them there. Here I am in Labrador listening to the canary singing in Brooklyn. Already you have the biggest part of the secret of the talking-machine.

"But the really amazing thing is the way in which we can shorten and lengthen the strings so cleverly, and at the same time regulate the wind pressure so accurately as to always sing the right note."

"How do we do it, father?"

"Well, we can't unless we practise—and then we can't always—just as I can't play the fiddle or piano like Kreisler and Paderewski, or sing like Caruso. But when they were born they couldn't play better than I could. (Picture 177.) All that any one of us four could produce then was a yell. Possibly they might have had better instruments than I, just as the grand piano is better than the old melodion. Though never forget the old saying: 'Genius is only one-tenth inspiration and nine-tenths perspiration.'

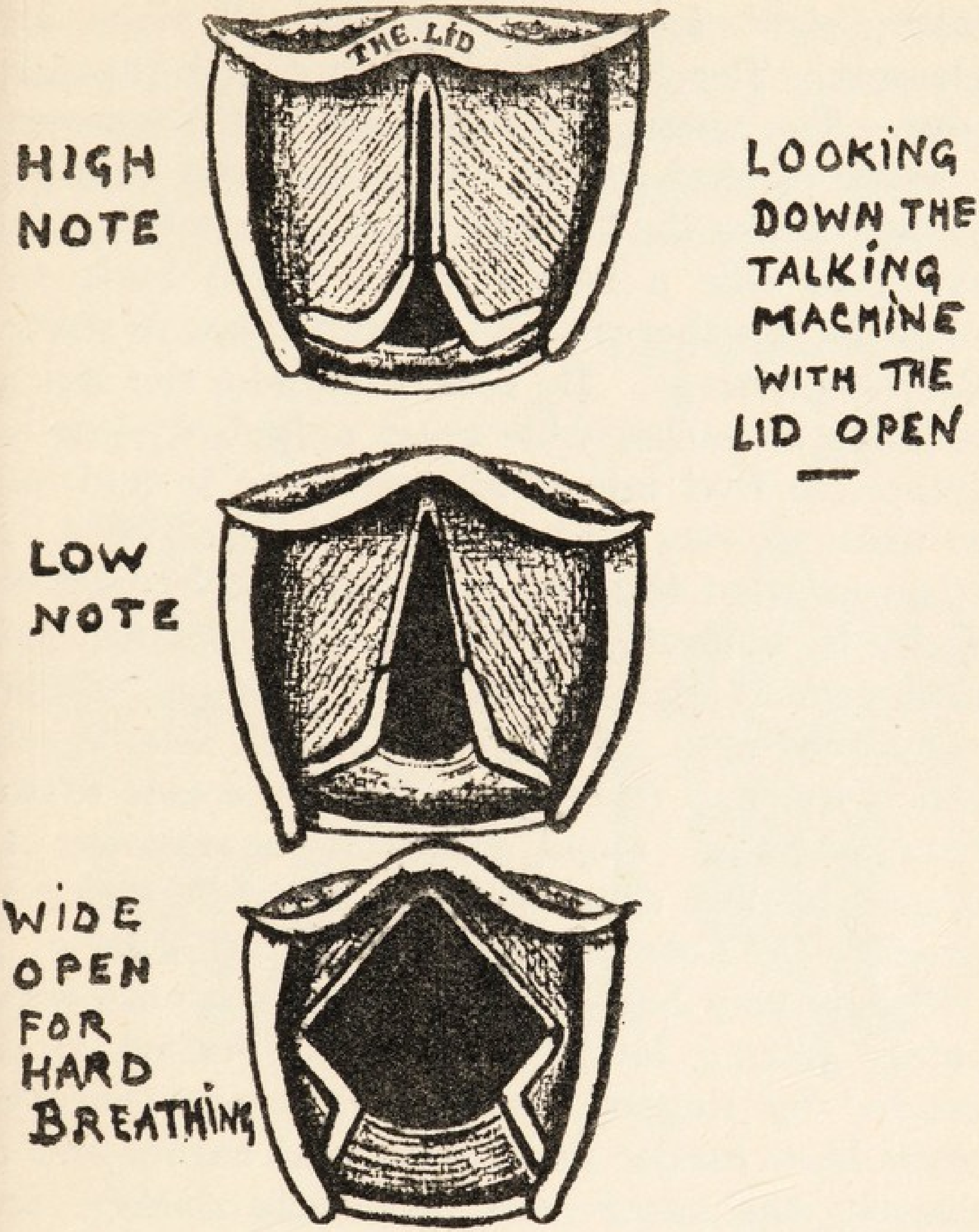
" A man's throat is bigger than a woman's and therefore his cords are longer and larger to begin

All that KREISLER, or, Paderzwski, or CAROSO, or I, could produce at one time was a "YELL"

177.

with. His are a little over half an inch long, hers are a little under, so his voice is deeper. That is why Wilfred's voice is so horrible. It is cracking. It only means his throat is very quickly growing larger just at present. The range of the voice is exactly like that of a string—it depends on its length.

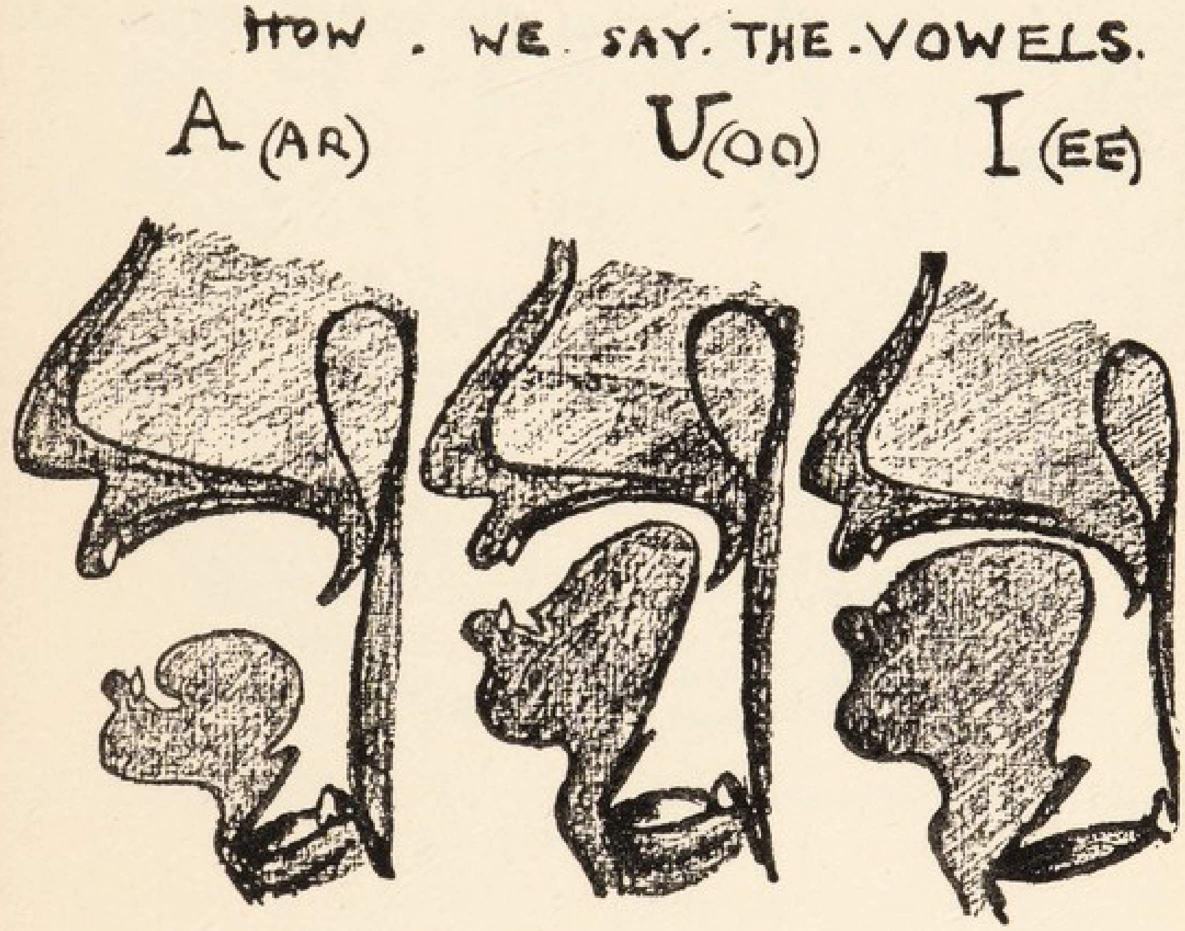
" Picture 178 is what I see with my instrument down the throat. It shows how the machine acts. The big ring is the case around the machine down



178.

the throat, and the tip in front is the top of the lid that closes when we swallow, and shoots our food over instead of into our talking and breathing machine. The same air is used to breathe and to talk. There is a beautiful little sack above the cords, right around. It is full of oilers and greasers. The flap above it is called the false cord. The thing like a swastika or boomerang is made of hard gristle. It is balanced on a ring of bone below the 'apple' bone or thyroid, and it can turn like a swivel. The whole bone and swastika together can also be tilted back to stretch the voice strings. By means of these the strings can also be pulled wide apart or pulled close together, so that lots of air can come in and out, as when we run hard and get 'short of wind,' or when we want to make low notes. (Picture 178.) There is, however, also another marvellous little arrangement to shorten the amount of the voice cord used. It is done by little muscle-cells inside the flap from the cord to the side of the bone, and that 'stops' it, exactly as we move our fingers up and down a banjo or fiddle string to produce the note we need. (Picture 176.)

"It is very hard to keep the same note accurately getting louder and louder (called 'crescendo' by singers), because it means that you must blow harder and harder and harder and at exactly the same time gradually slacken and slacken and slacken the strings. The real marvel is not that so many cannot sing well, but that so many can. All the same, good singers are very rare, and have to be paid huge sums of money. Though the width and length and tightness of the string alter the notes, really the sounding-box is the mouth and throat above, and the cavity of the nose. Your singing-master tries to teach you to use those sounders rightly, so that you may sing sweetly. The vowel sounds are made by wind that is not interrupted by anything. (Picture 179.) Only the shape of the mouth is altered.

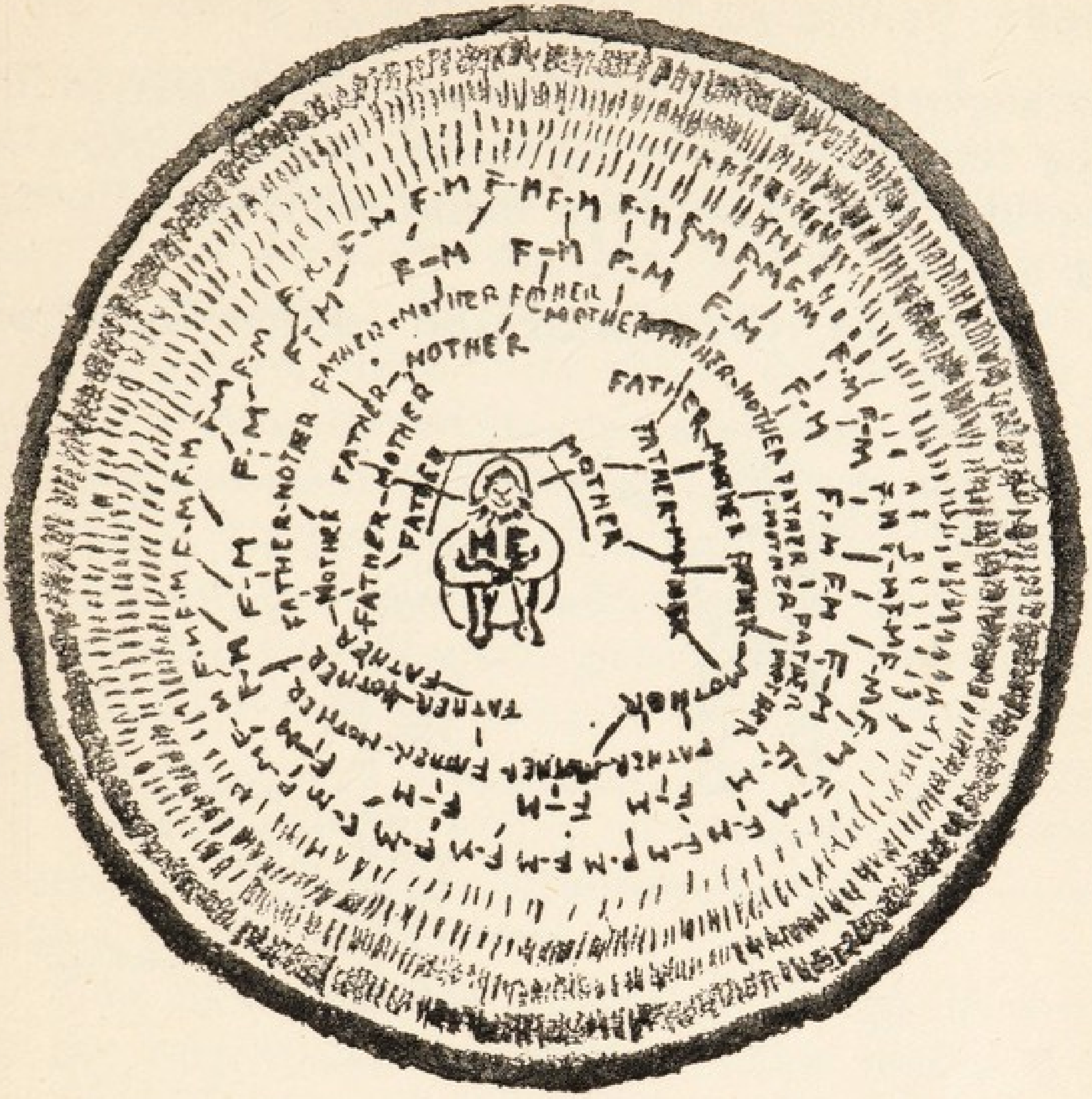


179.

But the consonants are made by stopping the air with the lips, teeth, and tongue. Thus, a snake hisses by pressing its tongue against the front of the roof of its mouth and blowing air between them. 'L' is the same, only you allow the air to pass each side of the tongue. 'R' is the tip of the tongue (or edge of lip or point of soft palate) blowing to and fro in the wind. 'TH' is made by placing the tongue against the teeth and blowing, etc.

"That is all. Run away, and when you are half a mile off try singing through first the back of your throat, and then in the front of your mouth, and then in your nose—then with your tongue against the roof of the mouth or in your cheek.

"Scoot!"



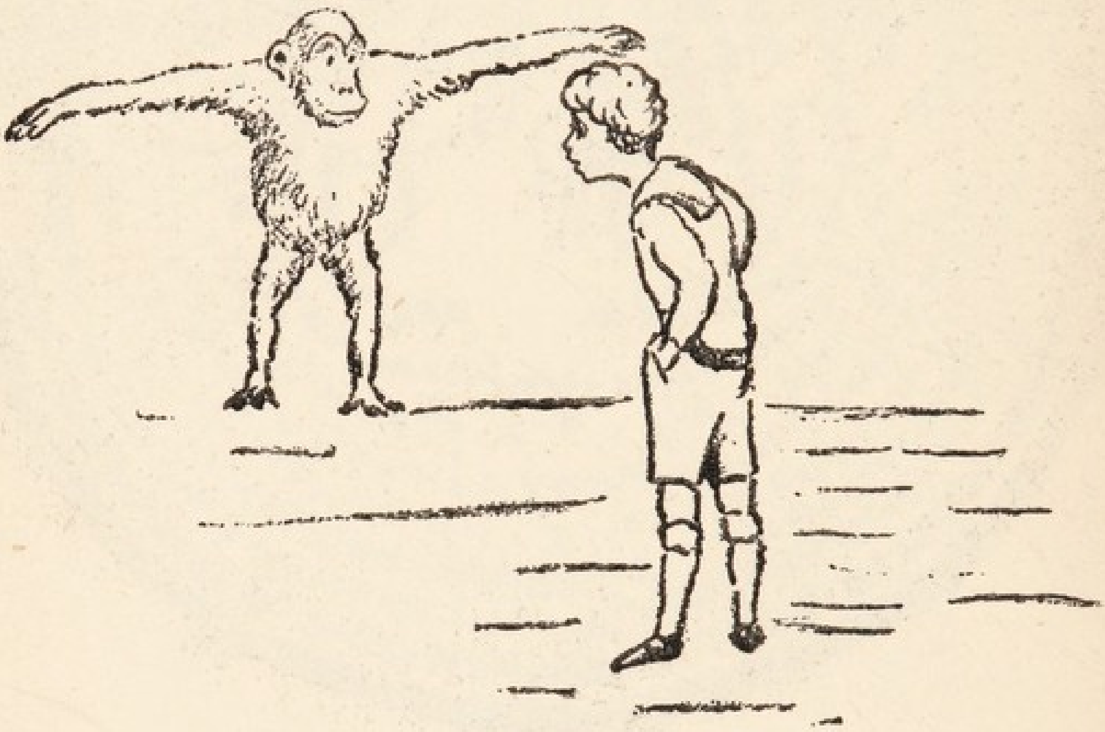
180. Ten generations. All these are Fathers and Mothers who helped produce ME.

CHAPTER XXIII

RENEWALS

"This is a world in which everything keeps moving until it dies and moves off altogether, as I told you. Therefore unless it is to become a desert waste and disappear, the most important of all arrangements must be that new things should all the time continue to be made, or born into the world. Otherwise there would soon be no world at all.

"You see, your father and mother each had



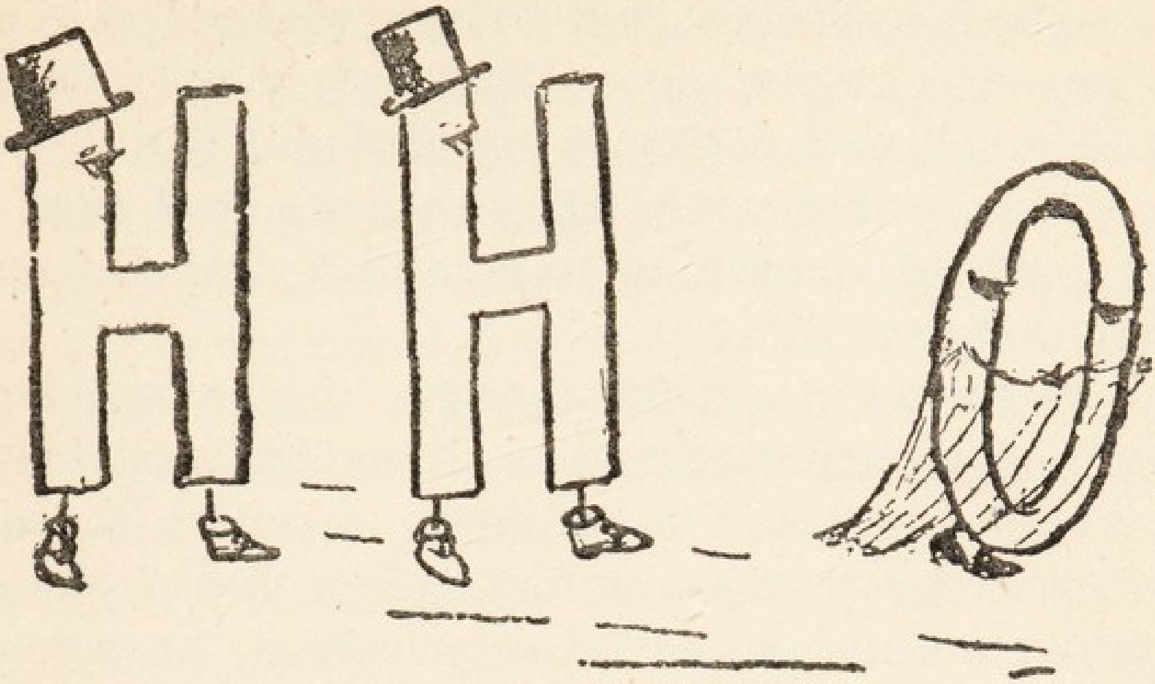
181. "Some people think we had monkeys' bodies once."

fathers and mothers, and their fathers and mothers had the same, and so on, for nobody knows how many ages back. (Picture 180.) Some even think we had monkeys' bodies once. But what does it matter so long as we don't act like monkeys? Anyhow that is the way a world like this has to be kept going, and it is the same with animals and plants. Not only are new things necessary, but better things are needed, and though the improvement is so slow that we do not always notice it, it is always going on. To-day men do not eat raw meat and live as naked savages in caves, unable to read and write, and they do not treat one another, openly, as cruelly as they used to. To-day they cook their food, live in houses, wash their skins, go to schools; and everything else advances with them. We keep growing more beautiful flowers and more wonderful fruits. Luther Burbank taught us how to grow seedless oranges and stoneless plums, and make thorny cacti thornless and good to eat; Stevenson showed us how to use steam; Wilbur and Orville Wright taught us how to fly, and so on. Thus the most important thing on earth is that new things should be born, and born better than ever before, all the while.

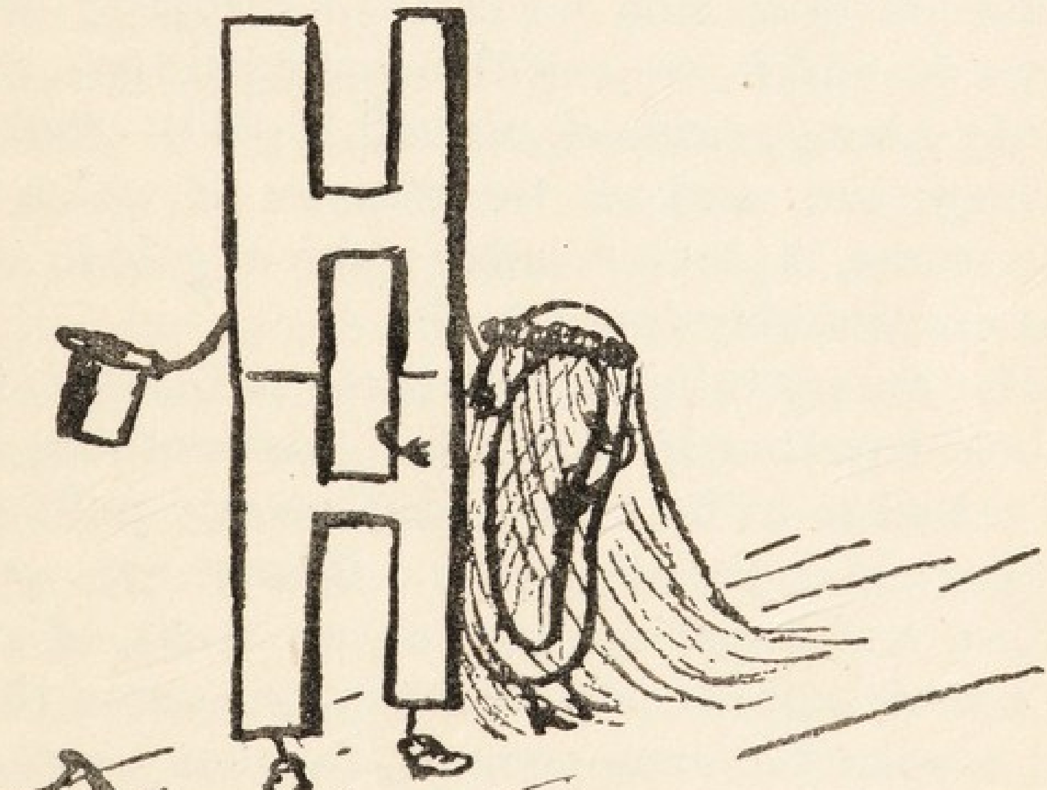
"The next thing to remember always is that we are responsible for all this. This makes the joy and dignity of being alive. If everything took place without us, we should be mere useless parasites, like the fungi, which sap the life of trees, or the miserable vermin that only suck the life-blood of living animals. So in the making of new bodies we have a great part and the greatest of all responsibilities.

"Much has been left to us. Have you ever thought that if we had enough strings in our ears so that we could hear every sound that fills the air, we should soon be stone-deaf? No instrument on earth could stand it. So it is left to us to invent the telephone, and gramophone, and radiophone, in order to catch and give us just the sounds we want; or the microphone or megaphone, to enable us to use louder sounds or hear those only when we want to which are so low that we could not otherwise know of them. Again, if the eye could see everything there is to be seen, how very soon we should all be blind. So to us is left to make ourselves microscopes and telescopes and fluoroscopes (X-rayscopes), so that we can pick out exactly what we want to see, and only when we want to see it, and also so that we can see through apparent solids. Still, again, if we were able to feel all the things that touch us, like our clothing, we should live in misery. So to us it is left to invent machines to measure tiny touches, like that of a lady placing her hand on a stone wall to detect how much she moved the wall, or how thick is a cell covering that is only one ten-thousandth of an inch across.

"We who dwell in these bodies are also entrusted with the even higher honour, that of helping to build a better world. Now if you take a bit of iron, or hydrogen, or even gold, all you can make out of it is iron or hydrogen or gold. However, if you have two different things, you can, in time, make many things—just as hydrogen and oxygen combined make a new substance altogether, called water (Picture 182)—or carbon and hydrogen make paraffin—or yellow and blue make green.



Two suitors for Miss Oxygen.



182. When united make one particle : H_2O.

So carbon, hydrogen, and oxygen make starch, or sugar, or vinegar, or a thousand other things. Take a cell and divide it equally and it will become two cells exactly like the first; but take a cell and add something to it, and it may become your body or mine.

"The most beautiful example in the world of this is when you study what all matter is made of. It is always made of two things. A centre like our sun, called a proton, or first thing, and a planet circling around it, called an electron, or second thing. Such an infinitely tiny thing it is that no eye can see it; but when one such planet goes around one such sun, we call it hydrogen; when two go around it, we call the result helium; when seventy-nine go around, we call it gold. Perhaps our huge sun, and all the planets of which our world is one, is just one small atom of gold in some to us unthinkably large world.

"One funny thing is that these sun and planets are held together by attraction, and nothing else, and yet seem to be, as it were, exactly pulling or working in opposite ways. These are called positive and negative, just as we speak of male and female, which is practically the same thing. It is a splendid arrangement, for many reasons, that two are required; for two heads are always better than one, more capable, more strong, more useful, more happy, more self-reliant. Suppose that every weed made a weed only. The world would be choked with weeds, and no one could live in it. But something comes in and alters the weed a little, and a bit more the next time, and so on until that poor weed may become a nice flower or a fruit, just as a thorny cactus has. Suppose that every egg made a chicken. The world would be stuffed with chickens, and there would be no nightingales and no other birds, no fishes (for they, too, come from eggs). Birds and fishes mostly lay their eggs as they are, because birds' and fishes' bodies are not nearly such delicate machinery as those of the higher animals, like dogs, or like ourselves.

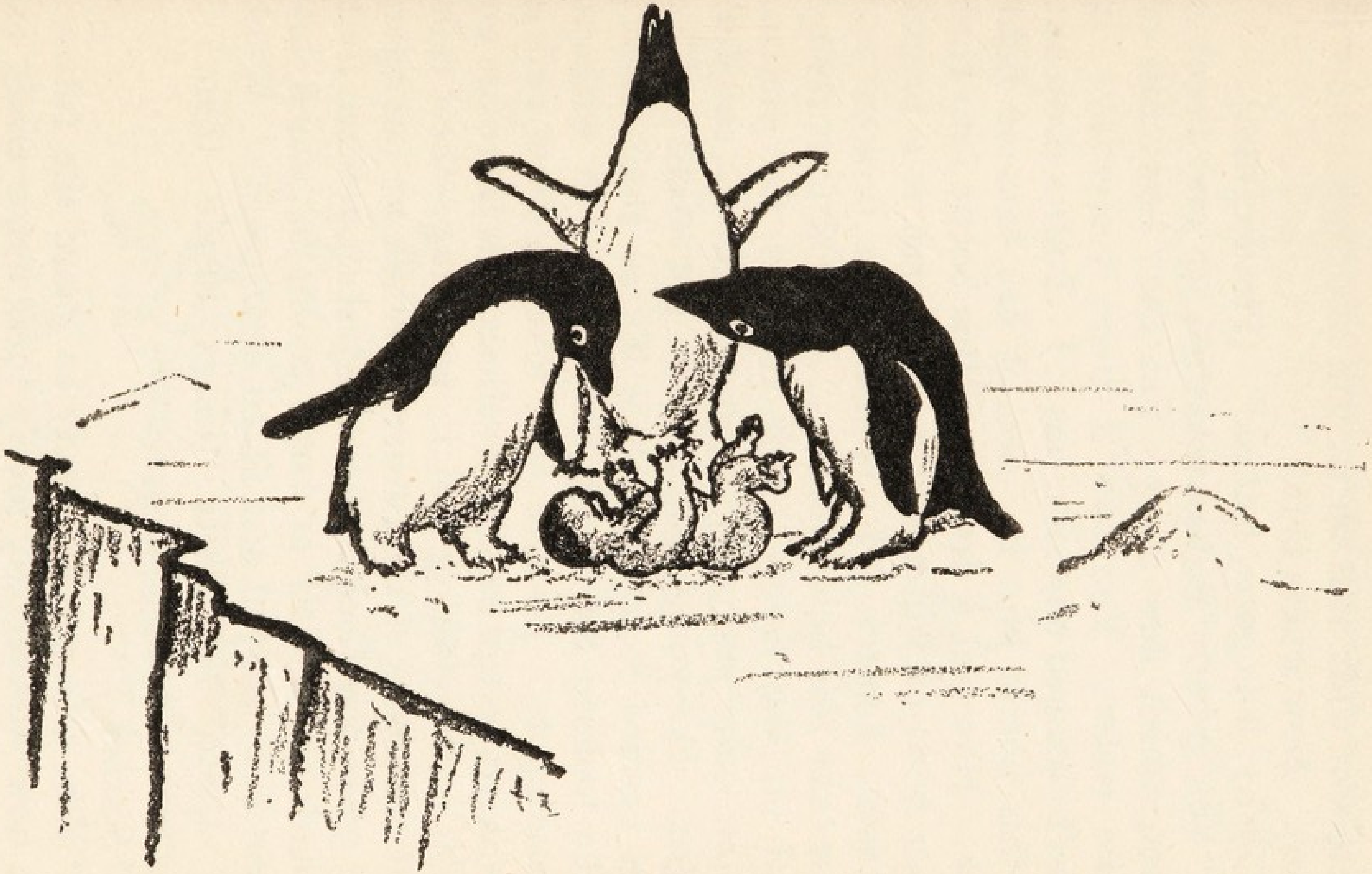
" Plants, also, can spread their eggs (or seeds) all around as soon as they are made, just as the dandelion seeds can be blown about in the air and tumble about anywhere without being hurt. They may get eaten alive by birds or animals, but they are so wonderful they can live all through the ' long red lane ' of a bird while they are carried to some new place, and then come out alive and grow better than if nothing had happened. But we cannot do that. We must be taken care of much longer by our mothers.

" It is a very long while before we are old enough to breathe for ourselves, or swallow for ourselves, or see for ourselves. A baby kitten cannot see for two or three weeks after it is born, and a baby puppy cannot feed itself for a month or more after it is born; but our babies cannot look after themselves for several years after they are born. There is nothing more helpless than a baby. (Picture 183.) If you have noticed, the more marvellous a thing is, the longer it takes to make; and, as a rule, the more it has to be taken care of by others.

"So that is how it is with us. When at last we come into the world mother has to feed us, and wash us, and take care of us, and then teach us, and clothe us, and, in fact, keep us alive until we are old enough to look after our own bodies. Then begins the hard job of looking after ourselves. That is the very reason that we are studying our bodies, so that we may learn how to make them better machines for our use in the world.

"Many people injure their bodies beyond all repair by not knowing anything about them. How many get rheumatism and heart disease because they do not realize that it can often be prevented by just taking care of their teeth and studying how and what to eat. How many burn their stomachs by drinking too hot things. A dog won't touch hot liquids.

"Now the next thing that I want you to learn is that if anything is left quite alone it will apparently stay exactly as it is. It is precisely as if the thing were asleep and never woke up. Here is a piece of chalk. For ten years it has lain in my desk, and is still only a piece of chalk. Pour



183. There is nothing so helpless as a human baby.

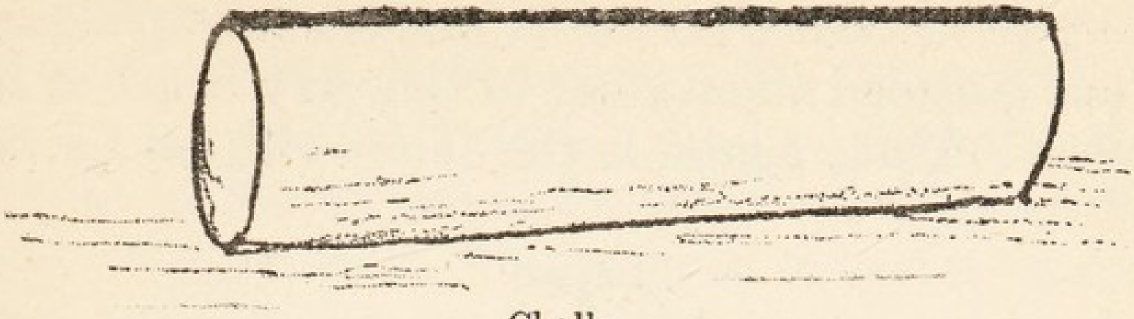
a little of that acid on it, will you? See how it fizzes. Now where is it?"

"Why, it is gone, father." (Picture 184.)

"Yes, gone. It has wakened up and become gases, which flew away. See that bowl full of white water. You saw it there yesterday. It hasn't changed one iota, has it? Pour a drop out of this bottle into it. See, it has become light blue. Now put a drop from this bottle into that other bowl of white water. It turns it a bright crimson, doesn't it? It has been broken up. Now take this beautiful lily. Look at that sticky stuff on the lovely green stem in the centre. What can you see? Some yellow powder. Right. Do you know how it got there? The bees carried it from another lily on their hairs; while looking for honey they carried it without intending to. So now that lovely yellow pollen is waking up the most marvellous cells there are on earth in everything and in anything—the 'cells that take care of the future.' When we cut open the green stem below the sticky stuff you see that it ends in a kind of large room, in which are beautifully shaped and fitted apartments. What are these big white things inside them?" (Picture 185.)

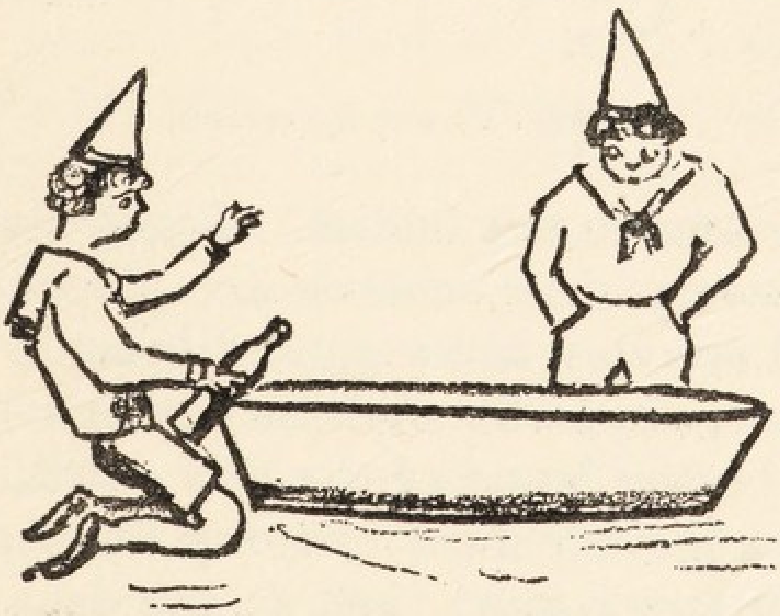
"Seeds?"

"Yes, cells getting ready to guard the future. See how wonderfully lovely their home really is. See how tenderly the plant devotes all its whole



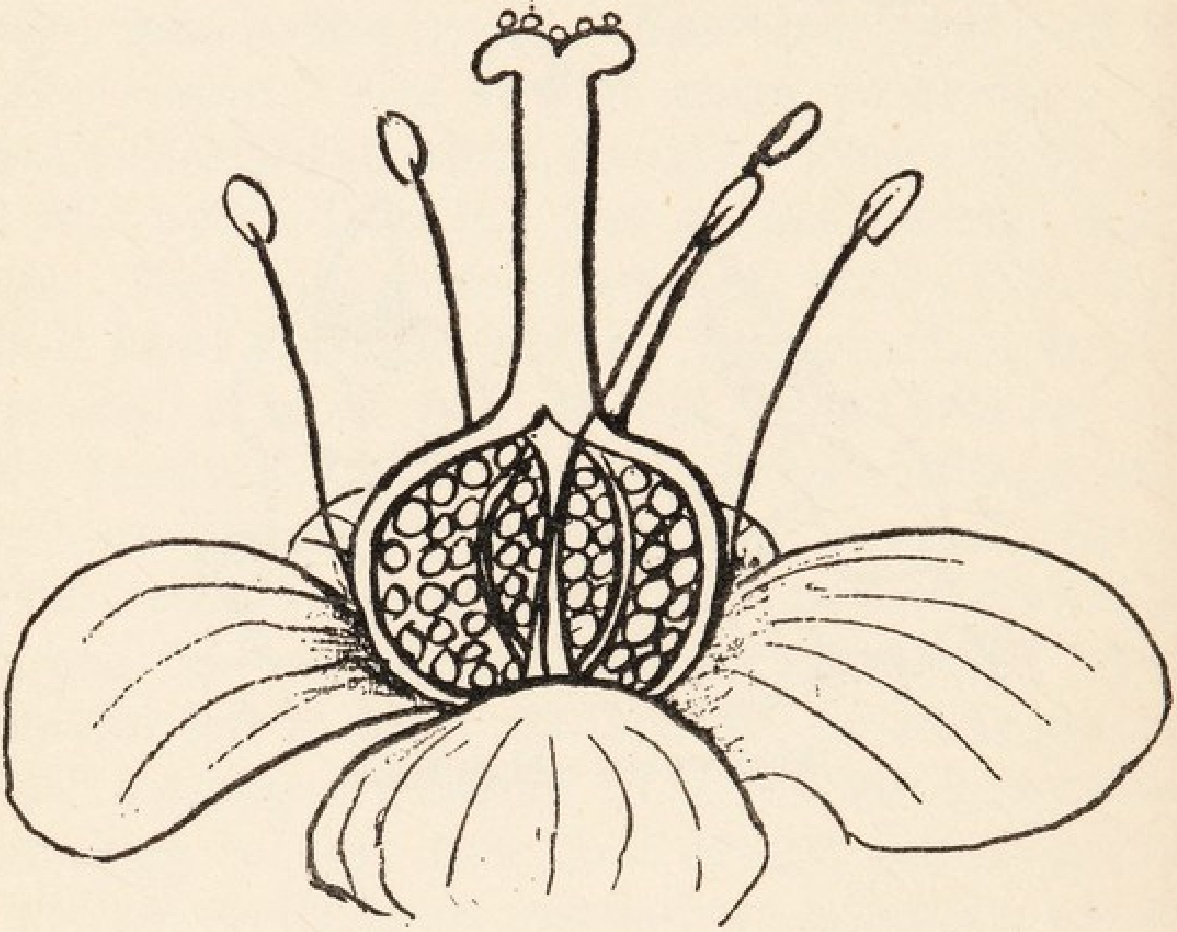
Chalk.

When we put acid on chalk.



184. All the chalk goes.

energies to caring for them, and see how jealously it has guarded them close to the very heart of the flower. That, again, is the same with all nature.



185. Flower egg-casket.

It is the same in our bodies. Right close to the heart of every dear mother are placed the cells that shall one day wake up and become the body of the new baby, who shall be born alive into the world to be the home of the new spirit, to whom father and mother must one day hand the torch, when their race is run; just as, my dear boys, one day, not far distant, we shall hand it to you, and look to you to bear it high.

"You are now at the age to look well to the bodies that mother and father gave you. Thank God, they are strong and perfect. Had we broken faith with our loved fathers and mothers, and been false to our high trust to try to build a better world, to-day you might be dwelling in miserable, deformed, or sickly bodies, handicapped for all your long journey through life.

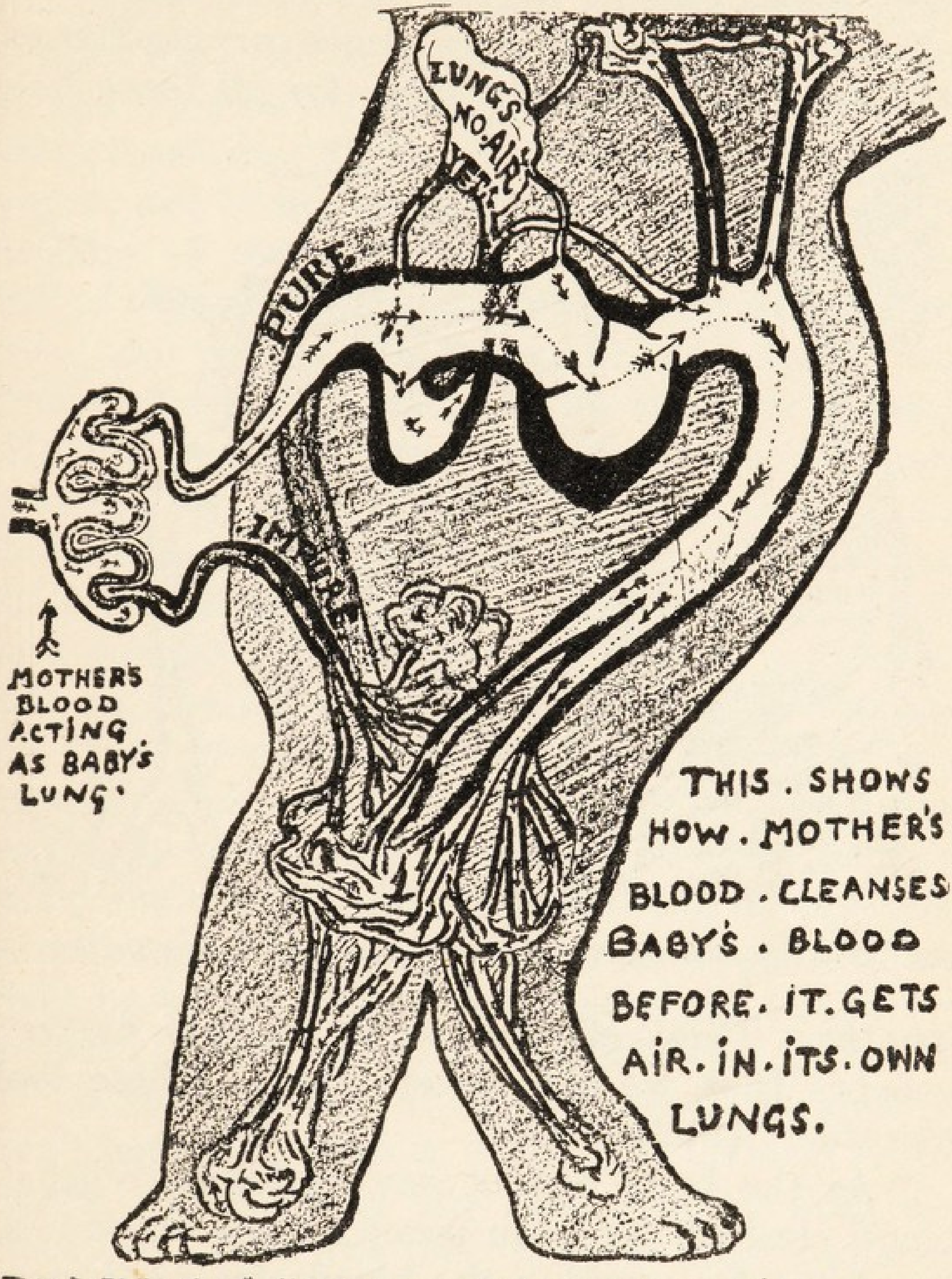
"What we are learning to-day is that the most important of all things on earth to you is that you keep your bodies ever pure and spotless. Life is not a terrible 'No Man's Land' which ends only in disappointment and death. It is a field of honour, and we are not slaves but knights, if we be but masters of ourselves.

"Now this most marvellous of all things on earth, this cell that will become a full-grown man or woman, a king perhaps, a George Washington maybe, a wizard like Edison, or a heroine like Florence Nightingale, is at first so small that it takes a hundred and twenty of them in a row to make a single inch. Think of it, your body was once only one one-hundred-and-twentieth of an inch in size; till, like the lily, or the Sleeping Beauty, it was awakened. Then a marvellous thing occurred. It started suddenly to grow large. One cell became two, two became four, till thousands of cells had been formed. Then the outside cells gradually built a covering which became the skin, and the middle cells set to work and became bones and muscles and machines of all kinds, such as we have been talking about. It is all built, something as a piano is built out of wood and wire and bone, or a dainty sailing yacht, or racy motor-car, out of common and simple materials.

"Meanwhile the inside cells of all, inside the growing mass, become the linings of the 'red lane,' of the lungs, the ducts, and many shops and factories and necessary machines. Then the outside cells dip in from outside and make a brain and spinal cord, and the eyes; and then close up the holes or trenches, and make hairs and nails and hundreds of needed things.

"Naturally all that cannot be done in a day. It takes nine months to make a baby's body ready to be born. A puppy dog's body can be made in six weeks. During all that time the growing body is floated in a special jewel-casket, so marvellous that it grows larger exactly as the contents grow bigger. Of course there is no air in the casket, so the baby body cannot breathe yet. Still, of course, it is a living body, and is growing, and must therefore get food and throw away waste and ashes, or else it would starve or be poisoned.

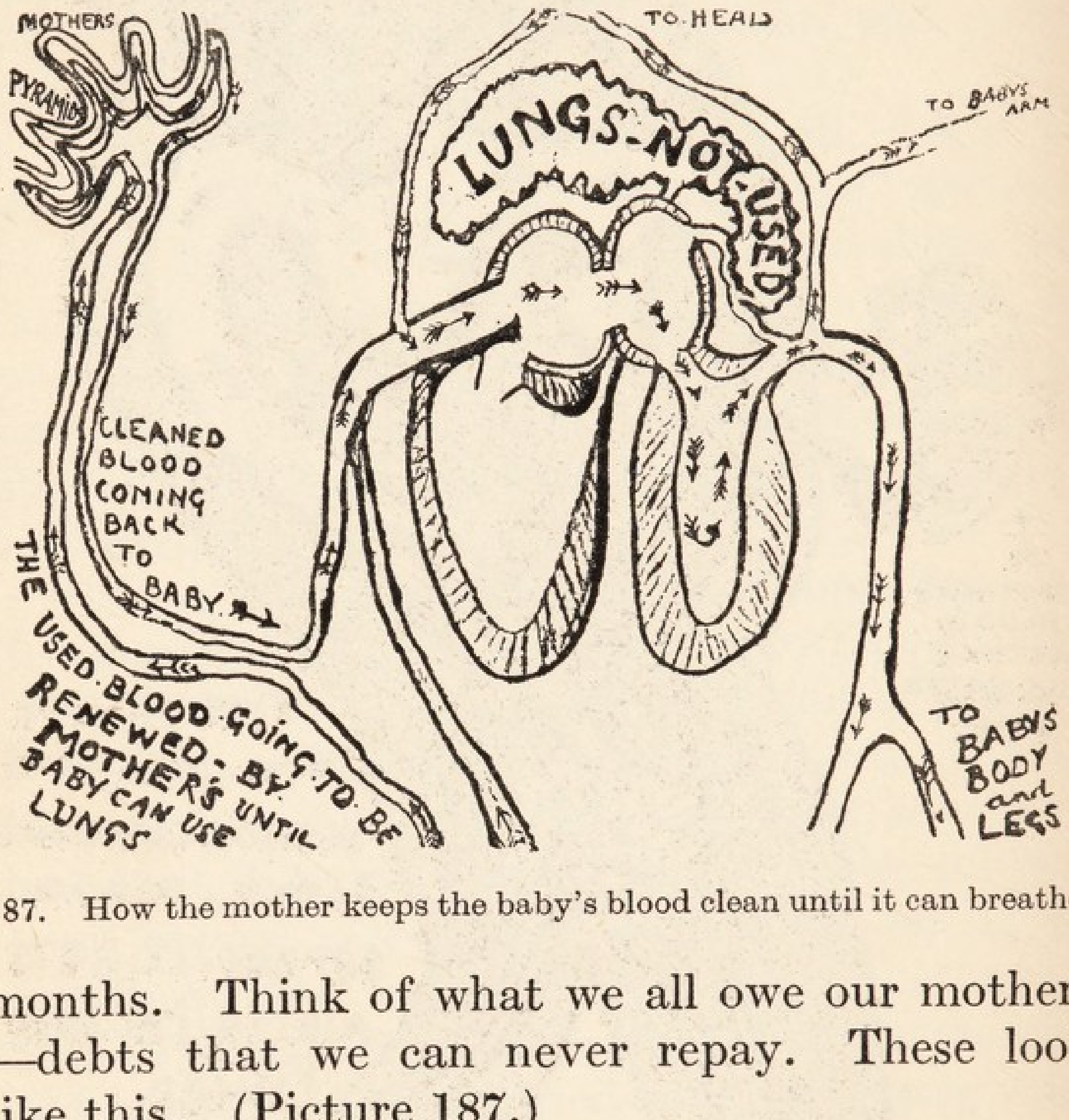
"The cells take care of all that. They rig up a wonderful arrangement so that the mother's heart shall drive the food around thousands of hollow pyramids in which the baby's blood is circulating, and so bring both oxygen and food, and carry



THE·DOTTED·VALVE·CLOSES.WHEN.BABY.TAKES.HIS.FIRST.BREATH.

186.

away waste exactly as you saw it in the lymph follicles, and in the hair tubes or capillaries. Mother's life is the baby's life for all those long



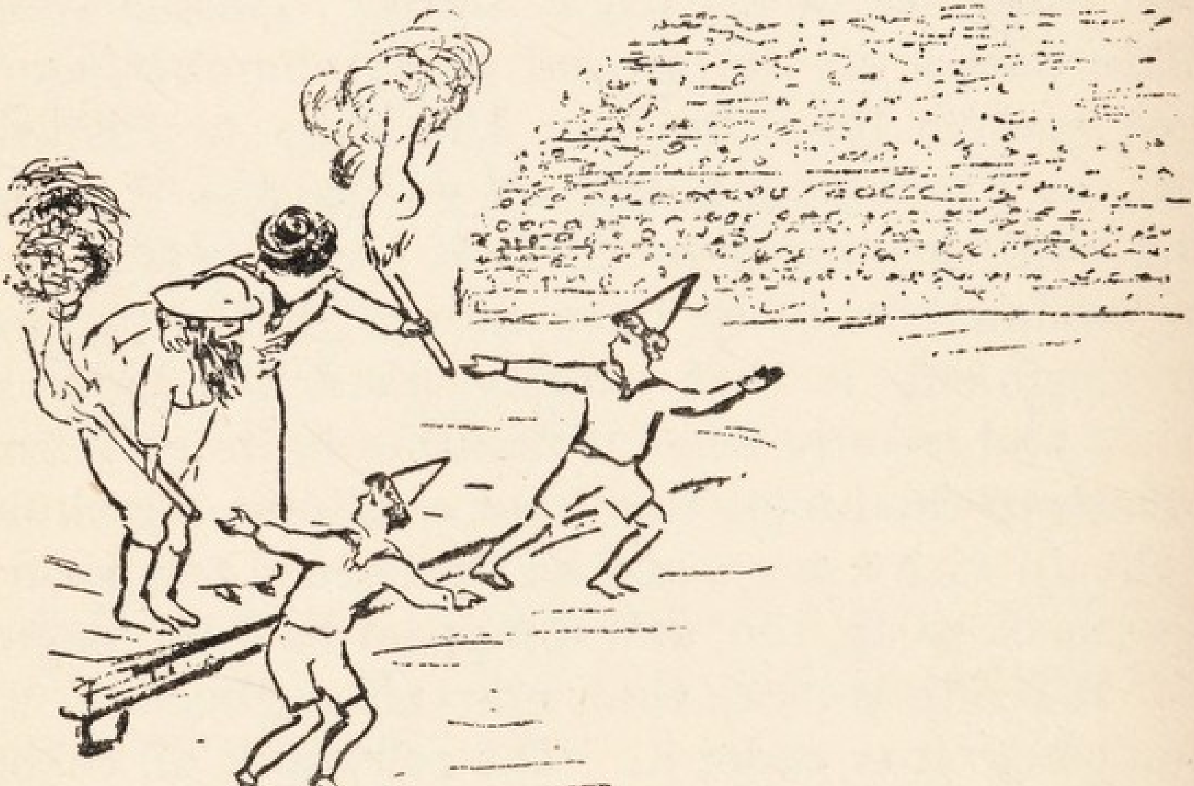
187. How the mother keeps the baby's blood clean until it can breathe.

months. Think of what we all owe our mothers—debts that we can never repay. These look like this. (Picture 187.)

"As the baby cannot use its lungs to get its blood cleaned, its main pump cannot accomplish its object by carrying the blood stream through them, as it does later on when air is breathed. So these same wonderful cells make another arrangement. A hole is left between the first two chambers of the two hearts, and the clean blood coming back through the veins or pipes from the pyramids, goes on through, and is pumped by the left ventricle or thick second chamber of the left pump, not to the lungs at all, but on through the arteries all over the body. Then it comes back full of carbons and waste in the veins as it always does, and pours again through the new pyramids, round which the mother's life blood is circling. There it is again enriched and cleaned, and runs into the big vein and back as before through the first chamber of the right heart. Thence some little passes to the second right chamber, only just enough for it to keep the lungs nourished; but, as I told you, nearly all goes across through the oval opening into the left heart again, and so round the body once more. The strangest arrangement is that exactly when the baby is born, and exactly when it breathes in its very first breath to the lungs, this large oval opening closes right up with a snap, and all the special temporary vessels close up, too, and disappear as if by magic.

" It really is more than marvellous, because we don't help it or order it. The cells do it all themselves. Very rarely the oval opening does not close up. Then the poor baby is blue, and soon dies, because then its pump cannot send the old blood through the lungs to be renewed, and mother can no longer help it.

" Later on we will learn more about all of these marvels, just as you will about all the rest of the machinery of which we have been talking during these 'Travels.' But remember that it is all machinery; and it is all the machinery that you have, and if you spoil it, you can never have another set. A lobster can grow a new leg when it loses an old one, but you cannot. And, above all, as I told you, if you damage your bodies you will do harm and wrong to others, perhaps for many generations." (Picture 188.)



188. In turn we all have to hand on the torch of life.

CHAPTER XXIV

DEFENCES AND DEFENDERS

" Some people think that man now knows it all —but the best scientists now realize we never shall do that on this earth. Thus we know there are what we must call 'natural' or 'absolute' units, beyond which we, on this universe, cannot go. One of these units is a velocity of 186,000 miles per second—the speed of light. Another is the absolute depth of cold, when there is no heat at all. Beyond these we cannot go. Moreover we are not yet wise enough even to know what all the things in our big machine are put there for. And though they go on working, we don't even know what it is they are doing. Only in 1923 did we find out what that sly fellow **INSULIN** was busy over. This shows how infinitely more wonderful than ours must be the wisdom that directed the making of our bodies and of our world. Nobody knows what consciousness is—we do know it is not necessary to the life of the body, because we go to sleep and become unconscious without the least fear. This potato is alive, but if I thought it was conscious I wouldn't care to eat it. We know that the sun attracts the earth, and the earth the sun—but we don't know why. We know this pen will fall down if I let go of it. We say, of course it will, 'because that is a law of nature.' But we don't know why it falls. Laws don't explain anything—they only state facts and leave us little wiser. So I must bring these talks to a close, leaving lots of things unexplained. As you ask me questions, I will collect them, and we will talk over the answers another time.

"To-day I want to say one word about defences. The best defence is prevention—far better than cure. The wisdom that built up our bodies knew that—and already we have spoken of many defences. Of the most wonderful, we have said but little. Amongst them come first the factories that have no ordinary outlet through a channel that we can see, but that, like the islands in the pancreas, slip their most wonderful secrets right into the blood stream. There are four of these chief factories—one in the neck called the THYROID. Man has now found out its messenger. He has called it THYROIDIN. It has much to do with control of growth, and its discovery is one of the great triumphs of science. A child who has, for any reason, no thyroid, is a stunted dwarf, ugly, and feeble-minded. (Picture 189.) Here is a picture of one taken by Doctor Osler, two years old, and here is the same three years old after a year's feeding on Thyroidin. Whereas, here is one fifteen years old who never

BABY. TWO YEARS OLD
WITHOUT THYROID
CALLED. A. CRETIN.

DR OSLER'S PICTURE.

SAME BABY
THREE. YEARS.
AFTER FEEDING
ON THYROID.

A CRETIN
15. YEARS OLD.
NOT TREATED

189.

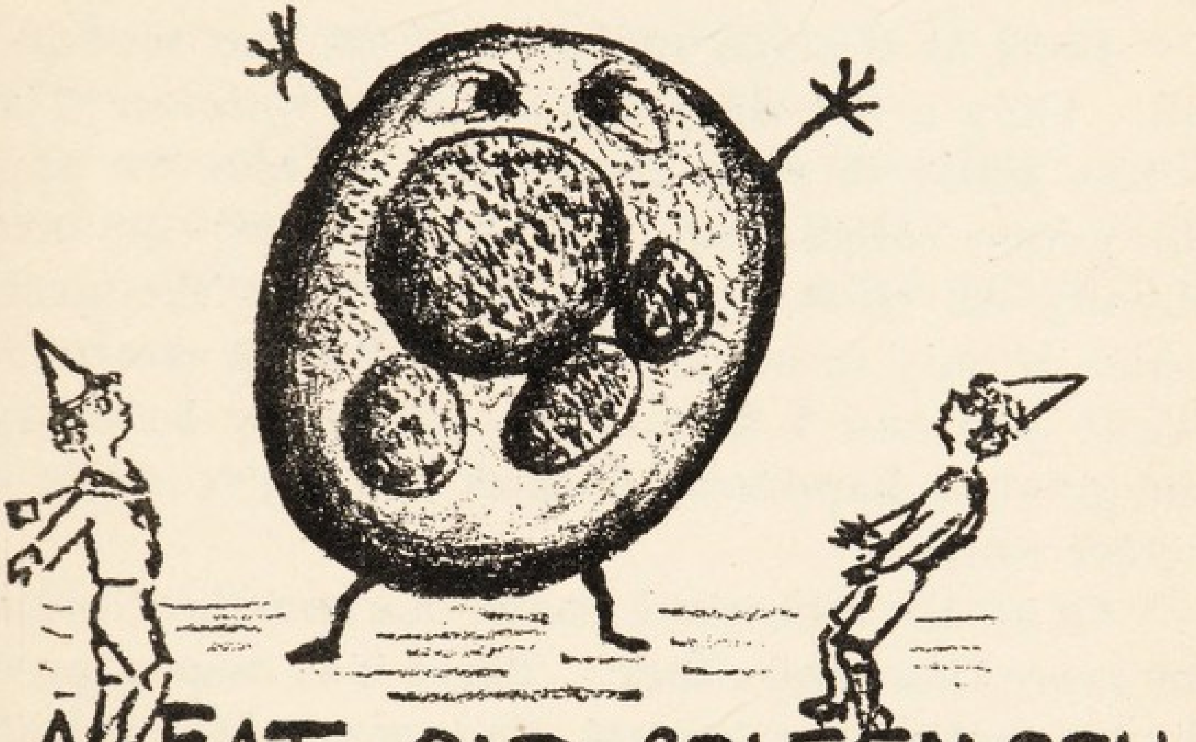
had Thyroidin. On the other hand, some people have too much, and would die if doctors didn't take away part of the factory.

" Then there are small factories called ' Near Thyroids,' but we don't know what they do, though we do know they are absolutely necessary. The tiny factories in the middle of the floor of the brain used to be thought to be the home of man's soul. It is called the ' Pituitary ' body. We now know that its secret messenger has a direct control of the pipes and pump—and also some influence on growth.

" On the very top of the kidney is still another factory. Its messenger we use a great deal to contract the small pipes and to stop *bleeding*. You have heard of it perhaps. We call it just ADRENALIN, which only means ON-THE-KIDNEY. The big spleen we know now is the great *filter* of the blood itself. Its cells also eat up dying reds, and probably help to make new ones. (Picture 190.)

" Of the other kinds of glands, there are nearly fifty, all built up much on the same principle, and in each there are specially trained cells to produce special products needed for some part of the body, and yet all these work together, for the body is really one unit. Protoplasm, like cement, actually unites cell to cell all over the body.

" The more complicated a town is, the more dependent one man in it is on another: the doctor on the lawyer, the lawyer on the doctor, the householder on the carpenter, and the carpenter on the householder, the mistress on the



190.

cook, and the cook on the mistress—each person does one thing that the others can't do. I have found educated men from great cities who would starve to death where a roving Eskimo will make a good living. The world can, however, only really get on by every one doing his part well. So remember the world needs you. You are not in it to get things, but to give things.

"You have been born for some purpose.

That, and that only, makes life worth while. For it is so short and, however much we get, we can carry nothing with us but the record of what we did.

" Look at this old robin's nest on the window-sill. Only a few days ago we were watching the robins build it with great care. Then we saw the young robins born in it, and to-day they are already all gone. And now we burn the nest, which is only so much rubbish and is in our way. While you and I have time, let us try to enjoy the greatest happiness, that of helping to make a better world.

" Of all the pictures I know, one somehow helps me more than any other. There was once a poor doctor, but a very earnest, fine man. He noticed that the lives of people who *milked cows* with a kind of rash on them, were spared, when that terrible scourge called 'smallpox' was killing one in ten of the population of the world. He loved his little baby boy as much as your father does. But he was so splendid a knight that after he had taken every possible precaution he decided to put some of the poisonous composition into the body of his own little boy to find out if it really would save children's lives. The picture is of him trying that—and it did all that he hoped. Doctor Jenner will never be forgotten, because directly and indirectly he has probably saved more human lives than any other man who ever lived. Abraham Lincoln, David Livingstone, Professor Pasteur, Lord Lister, most of the world's great men have been exactly like you and me, and like 'Mrs. Wiggs of the Cabbage Patch.' They did their bit! And so, as Longfellow tells us, we too, if we will, can each be a 'Hero in the Strife.'

"So begin by knowing all you can about, and holding absolutely sacred, your body; the only one in which you can face that great adventure that men call LIFE."

THE END