MURCHE'S SCIENCE READERS

BOOK III.

THE MACMILLAN COMPANY

SCIENCE READERS

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BY

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REVISED AND ADAPTED FOR USE IN SCHOOLS, WITH A PREFACE BY
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BOOK III

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PREFACE

Of this series of Science Readers, Books I, II, and III are adapted to Secondary Grades comprising pupils who are in their third and fourth years of school work. Both the reading and the subject matter of Books IV, V, and VI are suitable for Grammar Grades.

At the end of each of the first three volumes will be found a short summary of the lesson. This is a helpful feature. The teacher who reads this carefully, then the reading lesson itself, will secure both the needful knowledge and valuable suggestions for a successful method of imparting it.

Take, for example, Lessons III, IV, V. The teacher should read carefully the summaries and the lessons themselves. She should get from the poultry shop, quills, clothing feath ers, and down. Before allowing the children to read these lessons she should give lessons on the bird and its feathers, something after this fashion :

Let each child have in an envelope the three kinds of feathers.

What are they? How is each different from the other? Where is each found? Why?

Examine the quill. What difference between its two parts? Why? How are the barbs held together? Why?

Show the children pictures of the ostrich and of the eider duck, giving them additional information about their homes and manner of life.

After each series of lessons so taught, the part of the book relating to the subject may be used for supplementary reading.

Each lesson is illustrated in a way that will serve vividly to recall the teaching, thus emphasizing the important points.

The lessons are progressive, each one of a series being built on the facts taught in the previous lesson. Moreover, the subject matter —the properties of bodies; the nature, growth, and structure of plants; the common types of animals; minerals and metals; the phenomena relating to weather; in short, all the conditions which surround us—is exactly the science which should be taught in the elementary schools.

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BOOK III

Lesson I

Water—Its Properties

"We have not learned all about water yet, it seems," said Will, as the two boys trudged home from school.

"No," said Fred, "I expect there is plenty more for us to learn; and yet it all seems so simple when teacher leads us to look at the things in the proper way."

They had just been promoted again to a higher class, and that day the teacher had given the class the first object lesson of the new course. It was about the properties of water.

Our two boys seemed to have taken a new interest in life and in the things around them from the day they had their first object lesson. They had been through two courses of lessons, and were now about to commence the third.

"What are you so busy with, boys?" said Norah to them after tea.

"We are getting a few things ready for another chat about water," said Fred, "if you would like to join us, Norah."

"Oh yes," said she, "I should. But I can't think what else you can have to say about water. We know that it is a liquid, and that it dissolves things that are put into it, and that——"

"There, there, wait a minute, little girl," said Will. "Suppose you tell us why you call water a liquid."

"Oh, that's easy," said Norah. "First of all water has no shape of its own. It always takes the shape of the vessel which holds it. Then, too, it cannot stand in a heap, but always keeps a level surface.

"We cannot grasp water in our hands, to pick up a handful of it, as we could a handful of sugar or flour or raisins. The water would fall away in drops out of our hands and run along the floor, because water always flows down and tries to get lower. Everything that is like water in these respects is a liquid."

"I think she knows why water is called a liquid, Fred; so we may as well talk now about the other properties of water," said Will.

Fred had got several tumblers, just as he had seen his teacher do in class. He put clear water in one, and milk in another, and in the rest of them some water that he had colored with a few drops of red, black, and blue ink. He showed Norah these colored waters first, then the milk, and lastly the glass of clear water.

"Now, little girl," said he, "what color is water? You see it is not white; the milk is white. Neither is it black, or red, or blue."

"I don't think it has any color," said Norah.

"And you are quite right," said both the boys. "Water is a colorless liquid."

"Now," Fred continued, "look through the tumbler of water, and then through the milk. Can you see this ball through the milk?"

"No."

"Can you see it through the water?"

"Yes, I can see it through the water, but not through the milk."

"Remember, then, that water is transparent, milk is opaque. Water is a colorless transparent liquid. Milk is a white opaque liquid."

"And remember, Norah," said Will, "that we learn these properties of water through our eyes, by the sense of sight.

"Now, suppose we made you shut your eyes, and tell the names of various liquids, such as tea, vinegar, cocoa, coffee, brine, by smelling and tasting them, could you do it?"

"Oh yes, I am sure I could," said Norah.

'Then shut your eyes, and tell us the name of this one by first smelling it and then tasting it," said Fred.

"I can neither smell nor taste anything," said Norah.

"Now open your eyes and see what the liquid is," said her brother. "You see it is water. Water has neither odor nor taste. We say it is an inodorous and tasteless liquid; but we learn this through two other senses—the sense of smell and the sense of taste."

Lesson II

Some of the Uses of Water

"Now that we know something of the properties of water," said Fred, "we can talk about a few of the uses to which it is put. What do you think is the most important use which we make of water, Norah?"

"I should say," replied Norah, "that its chief use is for drinking purposes."

"Quite right," said Fred. "We could not live long without drink of some sort, and although we do not always drink water, yet all drinks are made of water."

"Yes," added Willie, "and animals and plants, as well as ourselves, require water or they would die.

"We must not forget, too, that our food has to be cooked and prepared with water.

"Then think of the great use we make of water in washing ourselves and our dirty clothes, and in cleaning our houses. Teacher says it is the natural cleanser. We cannot be healthy and happy unless we are clean. Dirt brings disease ; and the worst enemy of dirt is water."

"Now, I want you," said Fred, "to imagine what would happen if the water, instead of being colorless, tasteless, and inodorous, had a taste, smell, and color of its own.

"Picture to yourself our shirts and collars, everything we wear, as well as our floors and tables, and every article of our food, colored red or blue, through being washed or prepared in red or blue water.

"Think of the taste of our food too. It would take the same flavor and the same smell as the water in which it was cooked.

"Water is useful for all these purposes simply because it is colorless, tasteless, and inodorous."

"I have just been thinking," said Willie, "of what teacher told us about the water-cisterns. You know water is very absorbent, and will suck up and hold gases.

"Teacher told us that all rotting or decaying matter in dust-heaps and manure-heaps gives off bad gases. These bad gases would be sure to find their way into any water that was near, and we could not drink such water without being made very ill.

"The cistern which holds the water for drinking and cooking our food should be kept as far as possible from rubbish and manure-heaps, and bad smells of all kinds."

"There is one great use of water," said Fred, "that depends upon its being absorbent. Just think of the fishes and other animals that live entirely in the water. These animals all require air. Without air they would die."

"But how can they get air in the water, Fred?" said Norah. "Do they come up to the top every time they want to breathe?"

"No," said Fred, "they do not. Many of these creatures never come to the surface of the water at all. Yet they breathe freely, because there is plenty of air in the water.

"The water is absorbent. It is constantly sucking in air all over its surface. It is this air which the fishes and other creatures breathe."

Lesson III

Birds and their Covering

"We have not had a chat about animals for a long time," said Fred. "Would you like us to start one this evening, Norah? We had a good lesson on birds to-day, and I think Will and I can tell you something about it."

"Oh," said Norah, "I should like it very much."

"Well then, you remember we talked about several animals last year," Fred began. "We had amongst others the cat, dog, sheep, pig, horse, cow, and rabbit. Now think of them, one by one. What sort of clothing have they?"

"They all have different sorts of coverings," said Norah.

"Quite true," said Fred. "But all birds are clothed with feathers.

"Now I want you to think of something else. How do all those animals feed their young ones?"

"They nurse them," said Norah. "I have seen our Tabby nurse her kittens."

"Did you ever see a bird nurse its young?"

"No; the parent birds feed their little ones with bits of food which they find for them. Birds do not nurse their young."

"There is just one other point for us to notice now about birds," Fred continued. "All the animals we have mentioned live and move about either on the earth or under it. But what can you tell me about birds?"

"Birds fly in the air," said Norah. "They have wings."

"Quite right," said both boys. "Now, Norah, you know the three chief things about birds. Birds are the only creatures that are clothed in feathers. Birds do not nurse their young. Birds have wings and fly in the air."

"But let us fix our attention now," said Fred once more, "on the covering of feathers. This is the warmest, lightest, and, at the same time, the most beautiful of all coverings.

"Wait a minute while I go to the pigeon-house and get my little pouter. He is very tame, and will perch on my arm while we talk about his feathers."

Fred was back again in no time with his pigeon, and then he began. "Suppose we look first at the wings and tail. Notice these long feathers, as I spread out the wing. They have a stem, which we call the quill. These are the quill feathers. They are fixed into the skin of the bird by a sort of root. The bird makes use of these long feathers in the wings and tail for flying.

"Now, if you run your finger over the bird's body, you will find that the whole of the body is covered with smaller feathers, which form its real covering. These are the clothing feathers.

"Notice that when I run my fingers over them the wrong way, I ruffle them up; but they can be easily smoothed back again into their proper position, and then they are seen to be beautifully arranged, one overlapping the other, so as to form a close-fitting coat.

"Such a coat of feathers closely overlapping one another is of course very warm. But some birds, such as ducks and geese and swans, that spend much of their time in the water, both in winter and summer, are still further protected from cold. They have a close-fitting under-jacket of very small, fine, soft, fluffy feathers, which we call down."

"Yes," said Norah, "I have seen the down on the geese at Christmas time, and how tiresome it is to pick it all off clean."

Lesson IV

A Feather

"Where have you been, Fred?" asked Will. "We have hunted everywhere for you."

"I've been in the fowls'-house," said Fred, "to find a few feathers. Look what a fine lot I've got. They will do well, won't they?"

"Oh, I know," said Will. "You are thinking about our lesson. Yes, they will be just the thing. Where's Norah?"

In a few minutes the three were seated at the table ready for a chat, and Fred handed some of the quill feathers round.

"Now, a glance at one of these feathers," he said, "will tell us that it consists of two parts. There is the long stem, which runs from the root to the very tip of the feather; and on either side of this is the blade or web.

"Let us examine the central stem first. The lower half of it near the root seems tc be quite different from the upper half. Try and cut it across with your knife, Will." Will tried, but he found it no easy task to cut through this part of the stem, for it was like strong, tough horn. However, he did cut it across at last, and then they saw that it was really a round hollow tube.

"Teacher calls this lower part of the stem the quill," said Fred. "It is thin, hollow, and extremely light, but it is very tough, strong, and elastic, and will bear a great deal of rough usage. The lower end of it forms the root, which holds it in the skin of the bird.

"Now let us look at the other part of the stem. It is called the shaft. Suppose you strip your feather and then examine it. What can you say about it?"

"The quill of the feather is round," said Norah, "but this part has four sides. The upper and under sides are smooth, like the surface of the quill, the other two sides are rough. It was from these edges of the shaft that we tore off the web just now. I can see, too, that the shaft becomes smaller and smaller towards the tip."

"Quite right," said Fred. "Now we will go a step farther. Watch, while I cut through the shaft as we did through the quill just now. This part of the stem, you see, is not hollow like the quill. It is filled with a loose, white, tough substance,—the pith.

"We have done with the quill and the shaft now," he continued. "I want you to turn your attention to the other part of the feather, which teacher calls the web.

"If you examine this web you will see that it is made of a great many long, narrow, thin blades—the barbs. These spring from the shaft, and are arranged with their two flat sides close together.

"Pluck one or two of them. You can see that the edges of the barbs are provided with a great number of very small blades—the barbules. Barbule means a little barb.

"These barbules are really little hooks. They interlock themselves one in the other, and so hold the barbs of the web close together.

"Look, while I run my finger along the feather the wrong way. You see the little hooks are pulled apart, and the barbs themselves are separated from each other.

"Teacher showed us that the barbs always point towards the tip of the feather, and away from the quill; and, in addition to that, every feather on the bird's body points backwards.

"This is very important. As the bird moves through the air the feathers are pressed closer and closer to its body. This helps the bird in its flight, and, at the same time, keeps it warm."

Lesson V

The Uses of Feathers

"You have not forgotten our chat about feathers, Norah?" said Fred a few evenings later.

"Oh no," said his sister. "I know the three kinds of feathers which birds have—the quill feathers of the wings and tail, the body or clothing feathers, and the under jacket of down."

"Teacher has been showing us that all these are very useful to us in their own way. Shall I see what I can remember of our lesson?"

"Oh yes, do, Fred, please," said Norah.

"Well then, let us begin with the quill feathers. These are mostly used for adorning ladies' hats and bonnets. The most beautiful and costly feathers are the wing feathers of the ostrich, a great bird ever so much bigger than a man.

"In Africa there are large ostrich farms, where these birds are reared solely for their feathers, and I am sorry to have to say, Norah, that the cruel people of those farms pluck the feathers at regular seasons from the poor birds while they are alive.

"I suppose very few of the ladies who wear the beautiful feathers have any idea of the torture the poor birds suffer to provide for their dress. It always makes me very angry when I think about it."

"It's just as cruel to slaughter other birds," said Willie, "by thousands, as they do, for nothing else but their beautiful feathers. Of course it is always the most beautiful of the birds that they choose. If I were a lady I would never wear one of the dreadful feathers."

"I'm sure I never will," said Norah, with a shudder. "How cruel it is!"

"Teacher showed us some quill pens," said Fred. "They are made of the wing feathers of the goose and swan. We rarely see quill pens now. They are not so much used as they once were. Nearly every one writes now with a steel pen. But the quill pen is still used for certain purposes, and a small pen made of the crow quill is the best for some kinds of drawing."

"The clothing or body feathers of birds are very largely used for stuffing beds, pillows, and cushions. The birds which supply most of the feathers for this purpose are the poultry birds and wild fowl. They are killed for food, and the feathers are plucked from their dead bodies."

"I was thinking," said Norah, "of the great number of these birds we see in the shops about Christmas time. What an immense quantity of feathers there must be."

"Yes," said Fred, "and teacher says that, besides these, we bring in year after year ship-loads of feathers from other countries."

"Very little trouble is wanted to prepare them for use. All that is needed is to dry and beat them to remove dust, and then to bake them in an oven to kill the vermin in them."

"Do you remember what teacher said about the eider-down, Fred?" asked Will. "The down is got from the eider-duck, Norah, a wild sea-bird that makes her nest on the rocks by the sea, and lines it with down from her own breast. In this nest she lays her eggs.

"Each day men go round and take away some of the down and some of the eggs. Each day the bird plucks more down from her breast and lays another egg, only to have the nest robbed again and again, till she has no more down to spare.

"This may seem cruel; but the bird is not fit for food, and as we want the down, it is better than slaughtering the birds to get it."

Lesson VI

Water as a Solvent

"I suppose," said Willie, "teacher only wanted to find out to-day how much we remember of our early lessons. He went over all the old work."

"Yes," said Fred, "and as soon as tea is over I am going to try Norah. I wonder whether she has forgotten all about it."

As soon as they were free, therefore, the boys got a few things together, and Fred began just as their teacher had begun in class.

"Look, Norah," he said, "I have here a piece of coal and a piece of salt. If I put them into water can you tell me how they will act?"

"Oh yes," said Norah. "The salt will dissolve in the water, but the coal will not dissolve."

"But what do you mean by the word dissolve?" he asked again.

"The word dissolve means to loosen or separate," replied Norah. "The water has the power to loosen and break up, or separate the solid salt into such tiny little particles that we cannot see them. When it is broken up into these tiny particles, we say the salt is dissolved. The water cannot break up the coal. It will not dissolve."

"Do you know what we say about the salt because we can dissolve it in water, Norah?"

"We say," replied Norah, "that the salt is soluble. The coal is insoluble; that means not soluble."

"What other substances will dissolve if we put them in water?"

"Sugar, soda, alum, and lime all dissolve. They are all soluble substances," said Norah.

"Now tell us what we say about the water that dissolves these things?" said Fred.

"We say that water is a solvent for sugar, salt, alum, lime, and any of the things which it dissolves," said his sister.

"See," Fred continued, "I can take the coal out of the water just as it was when I put it in. But can I take the salt out in the same way?"

"No, the salt cannot be taken out, because it is broken up into very small particles, and the particles are scattered through the water."

"Could I get the salt out of the water in any other way?" asked Fred.

"If you boiled the water," said Norah, "it would all pass away as steam, and the salt would be left behind."

"Do you remember," Fred asked again, "that we once filled a tumbler with water to the brim, and then put in salt, a spoonful at a time?"

"Oh yes," said Norah, "and I thought you were so clever. I could not make out how you were able to put all that salt in without spilling any of the water."

"But you know now, Norah, don't you?" asked Will.

"Yes," said Norah, "you told me all about it. The water is porous and absorbs the tiny little particles of salt into its pores."

"That's right," said Fred. "The tiny dissolved particles, after being broken up and scattered in all directions, fill up the pores in the water. When the pores are all filled the water can hold no more, and the rest of the salt falls in a solid wet mass to the bottom. Remember that water absorbs air and gases in the same way by sucking them up into its pores."

Lesson VII

Further Uses of Water

"I wonder what can be the matter with Norah," said Willie, as the two boys came in at the garden gate one afternoon from school.

She was sobbing and crying, while the big tears rolled down her cheeks.

"Oh, Fred," she cried, "look at my pretty window boxes. I forgot to water them yesterday, and the sun has been so hot to-day, that all my beautiful flowers look scorched up and dying. Can we do anything for them? I am so sorry."

"All right, little sister," said Fred; "crying won't do any good, so dry your eyes and let us see what can be done for them. Here, Will, you go and get a pail of water. The best way to revive them is to stand them in water just as they are, pot and all, for about ten minutes."

Fred took the flower-pots down, one by one, and stood them in the water. After giving them a soaking in this way, he put them back in their places, and then it was time to go in to tea. When tea was over, and they got out again, many of the plants were already holding up their heads, and the rest of them looked to be reviving rapidly.

"Now, little girl," said Fred, "while we sit here and watch your plants, let us have a chat about them. Do you know why they were drooping and dying?"

"I suppose," said Norah, "it was because they were thirsty and wanted water."

"Yes," Fred replied, "that's right. But it was worse than that. They were not only thirsty through the great heat; they were dying, because they were actually being starved in the midst of plenty of food.

"The soil in the flower-pots contained abundance of food, of exactly the kind they required; but it was useless to the plants till it had been dissolved by water.

"By soaking the pots a few minutes we dissolved some of the substances in the soil, and then the little roots were able to suck up those things in a state of solution.

"You know that the root is the feeding organ of every plant. You will now understand that, but for this solvent power of water, no single plant could live and grow."

"I have always noticed," said Norah, "how fresh and bright and beautiful the plants in the garden look after a shower of rain."

"Yes," said Fred; "they do. But you must remember that it is not the rain itself that does this.

"Teacher was very careful to show us that the rain-water is nearly pure, and contains no substances in solution. Such water could not feed the plant.

"It is only after it falls, and sinks into the soil, that the rain becomes useful to the plant. It is useful then because it dissolves the plant-food in the soil."

"Teacher explained to us, too," said Willie, "that this same rain, after passing through the soil, continues to sink down deep into the earth. It trickles through rocks of various kinds, and dissolves, on its way, all that is soluble.

"By and by the same water bubbles up out of the ground again, and forms a spring.

"Teacher says this spring water always contains some solid substances or other in a state of solution.

"The waters of some springs contain such mineral substances as iron and sulphur in solution. These are known as mineral springs. The waters are used as medicines."

"You remember," said Fred, "our talk about the glass of sparkling spring water. Does that spring water contain any substance in solution?"

"Yes, it has lime dissolved in it," said Norah. "We cannot see the lime, but we can find it as a thick coating round the sides of the kettle, in which the water is boiled. We call it 'fur'; and we say that the kettle is getting 'furred.'

"Oh," Norah continued, "I remember, too, about the brine springs which supply us with salt for the table. The water of these springs fell at first as rain, and as it sank through the earth it dissolved the salt that was there, and carried it away in solution."

"Then, again," said Will, "the sea is salt too, and it gets its salt in the same way.

"Teacher says the sea is fed with water by the rivers, which are constantly flowing into it; but the water of all these rivers is fresh, not salt water. It fell in rain from the clouds. It got its salt by dissolving it out of the substance of the earth itself."

Lesson VIII

Birds

"Suppose we have a chat about birds this evening," said Fred. "Can you tell me, Norah, why all birds are clothed with feathers?"

"Feathers make the lightest of all dresses," said Norah. "Birds have to raise themselves in the air and fly, and a thick heavy coat would prevent them from doing this."

"Quite right, and so would a thick heavy body, wouldn't it? Teacher has been showing us that the bird's body must be light as well as its clothing.

"If we compare the bones of a bird with the bones of some other animal about the same size, we find a great difference. The bones of the bird are very much lighter.

"You would find out the difference by holding Will's guinea-pig in one hand and my pigeon in the other. I am sure it would surprise you.

"The bones of the bird are all hollow, and at the same time they are very light and thin.

"Now let us think of the build of the bird's body. We ourselves, as well as the animals about us, have two pairs of limbs. So has the bird; it is built on the very same plan, except that it has wings instead of arms or fore-legs.

"Teacher made us compare our own arm and hand with the wing of the bird. We have an upper arm, a fore-arm, and a hand. The bird has all these parts to its limb, but the bones are lengthened to make a wing for flying."

"Do you know which part of our lesson pleased me most, Fred?"

"I suppose you are thinking about the mouths and feet of the birds," said Fred.

"Yes, I am," replied Will, "for I can't help thinking that it is very wonderful.

"You know, Norah, we learned a long while ago to look into the mouths of animals when we wanted to find out all about them, their food and their habits. The teeth of the animal tell us all we want to know.

"Teacher showed us a great many heads of birds. They all have hard horny beaks or bills instead of mouths; but the bills are not all the same shape.

"The bill forms mouth and teeth all in one, for birds have no real teeth. We call the two parts of the bills the mandibles.

"Teacher says the bills are not all alike, because the birds themselves are not alike in their nature, their habits, or their food.

"Just as we learned to do in the case of other animals, so shall we have to do with the birds. We must examine their mouths to learn what we want to know about them.

"You remember too, of course, that in all our old lessons we found the feet as important as the mouths. We always examined the feet. Teacher told us to-day that we must learn to do the same with the birds.

"He showed us some pictures of birds' feet. They were all different from the feet of any other animal. We call birds' feet claws.

"Although all birds have claws, there are many ways in which the claws of one bird differ from those of another.

"Teacher says that in every case the nature, habits, and food of the bird depend upon the form of the claws, as well as upon the bill."

Lesson IX

Water in other Forms

"Look, Fred, how the steam is puffing out of the spout of the kettle," said Norah, as they sat round the fire.

"Yes, dear, I put the kettle there myself," said Fred. "I wanted you to notice it, for we are going to have a talk about the steam now.

"What would happen if we left the kettle on the fire?"

"The water," replied Norah, "would all boil away, and the kettle would be left dry."

"But what does that mean?"

"The water would be changed into steam," said Norah.

"I think," said Fred, "I had better explain it as teacher did. He says that steam is only water in another form. The heat breaks up the water into such extremely small particles, that they are lighter than the air itself. They therefore rise in the air and mingle with it."

"But what becomes of it in the air, Fred?"

"The air is very porous," replied Fred. "It absorbs into its pores these little floating particles, just as water absorbs salt.

"You have seen mother hang out the wet clothes on washing day, and you know that after a time she is able to take them in quite dry. What has become of the water? I will tell you. The water in the wet clothes on the line has been broken up into tiny particles—not of steam, but of something like steam. We call it vapor.

"These little particles of water-vapor, like the particles of steam, are so light that they rise in the air, and are at once sucked up or absorbed into its pores.

"We say that the water evaporates. We mean that it changes into vapor."

"I have seen the water evaporate after a shower on a very hot day," said Will. "The vapor rises in a cloud from the wet pavements, and in a few minutes the stones are quite dry. On a cold day, too, the pavement dries up, but not so quickly as in the hot summer weather."

"But you see," said Fred, "if it dries up at all, it proves that even in the cold weather the water evaporates. Let me explain it to you. It is the air which carries off the water, and it does this because it is porous and absorbent.

"Sometimes the air is so very dry that its pores contain little or no vapor. When this is the case the air becomes very thirsty. It will break up the water into tiny particles and suck them at once into its pores.

"The drier the air is, the quicker will be the evaporation. Clothes will dry on the line in cold weather as quickly as in hot, if the air is dry.

"When the pores of the air are already loaded with water-vapor, it is very little use to hang the clothes out. They will not dry. The air cannot take in any more water, because its pores are already full. No evaporation can go on. The water remains in the clothes."

Lesson X

Vapor in the Air

"Come to the window, Norah," said Will, "and you can see the very thing we were talking about the other day. The rain is over now, and there is so much vapor rising that the ground seems to be steaming. The air must be very dry and thirsty, for the sun has been hot, and a great deal of the rain which has fallen will evaporate. But will it all evaporate, Norah?"

"No," said Norah. "Some of it will sink into the ground, and after a time bubble up again in the form of a spring. We can see too some of it is running away in streams along the gutters to the drains."

"Yes," said Fred, joining in, "and the drains will carry it away to the river, and so to the sea. The whole of the water which drains off the land flows away and forms rivers, and the rivers pour their water into the sea. So that in the end it all comes to the sea.

"Teacher made us think about those great bodies of water—rivers, lakes, oceans—all over the world, with the thirsty air all round. You have seen evaporation going on from the wet ground after this shower of rain.

"What an immense amount of vapor must be always rising from the great surface of the sea. The air gets most of its vapor from this one source.

"Don't forget that evaporation goes on over every part of its surface. Of course it is more rapid in the hot parts of the world than in the cold, but even in the cold regions there is evaporation."

"Teacher gave me a surprise, Fred, about the plants," said Will.

"Yes, Will, I think most of the boys were surprised to see that bottle," replied Fred.

"What was that?" asked Norah.

"Teacher showed us a bottle with some fresh-cut leaves in it. He had put the leaves into the bottle and corked it up tight before he left home for school. The bottle was perfectly dry when he put the leaves in, but when he showed it to us the whole of the inside was covered with little drops of moisture."

"Then, of course," said Norah, "the moisture must have come from the leaves."

"Yes," replied Fred. "Teacher says all plants give out moisture, and this moisture is changed into vapor and absorbed by the air.

"Think what a quantity of vapor must be formed and sent into the air in this way by all the trees and plants that grow on the earth.

"But animals as well as plants help to fill the air with vapor," continued Fred. "Teacher made us think of a horse drawing a heavy load. You must often have seen a horse at work covered with drops of moisture or sweat. You know that we ourselves cannot work hard or run about without perspiring. We find the sweat drops on our own bodies.

"Now what do you think becomes of all this moisture ? I will tell you. It evaporates, and the air absorbs the vapor as it forms."

"Oh yes," said Norah, "I have often seen a horse's body steaming with vapor when he has been working hard."

"And not only his body," said Will, "his breath too gives off clouds of vapor. We can see it every time he breathes; and we can see the same thing if we watch our own breath. It is always loaded with vapor."

Lesson XI

Birds and their Beaks

"What do you think of the lions and tigers of the air, Will?" asked Fred one evening.

"Lions and tigers of the air!" said Norah. "Whatever do you mean, boys?"

"We mean that teacher has been giving us another lesson on birds, and he calls some of the birds the lions and tigers of the air," said Fred. "I think it is a very good name for them too.

"He commenced the lesson by showing us a picture of a bird's head. The first thing that struck us about this head was the great, hooked, and pointed beak. It looked very strong, and seemed just suited to the piercing eyes and the fierce, cruel-looking face of the bird.

"Teacher says this bird is as fierce and cruel as it looks. It lives on the flesh of other animals, and its strong, hooked, pointed beak is just fit for the work of tearing them to pieces.

"You may be sure I thought at once of the fierce flesh-eating beasts, and their sharp, cruel teeth; and it was just then that teacher told us we might call all birds of this kind the lions and tigers of the air, or birds of prey. He says they hunt their prey in the air just as the beasts of prey hunt their victims on the earth.

"It was the picture of an eagle's head that teacher showed us. The eagle is the king of birds. Amongst the other birds of prey are vultures, hawks, falcons, and owls."

"I think Norah would have been pleased with those fishing birds," said Will.

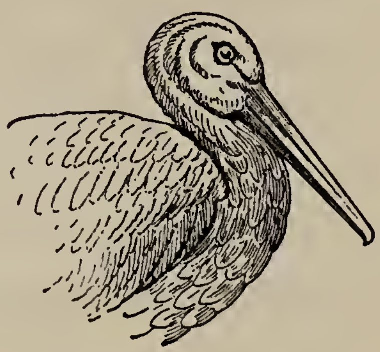
"What are they like?" asked Norah. "Are they fierce and cruel too?"

"Well, I don't know that they are fierce," said Will, "except perhaps to the fishes, frogs,

and other creatures of that sort, which they catch in the water for their food. But they seem to be fitted in a very wonderful way for the life they have to lead.

"These birds are always found in marshy, swampy places, or by the banks of rivers, because it is only in such places that they can find the animals on which they feed. They have long, slender, pointed beaks.

"They are very keen of sight, and most clever at their fishing. No sooner does the bird catch sight of its prey in the water than it darts upon it like lightning, pierces it through with that sharp, pointed beak, and brings it to the surface.



"The stork, heron, and crane are fishing birds."

"I think the woodpecker is a very wonderful bird," said Fred. "This is a bird that feeds on worms, grubs, and insects, which eat their way into the trees. It cannot, of course, see these little creatures inside the stem of the tree, but it seems to know exactly where to find them.

"It has a long, straight, pointed beak, very hard and strong. It finds out its prey by tapping on the bark of the tree with its beak and then listening.

"As soon as it is sure of finding its prey, it begins to bore through the bark with its strong beak till it comes upon the spot where they are. No other beak would do this boring work so well. Then the woodpecker's tongue becomes a wonderful help to him. The tongue is long, narrow, and pointed, and the bird is able to thrust it out suddenly a long way beyond the beak.

"When the beak has bored the hole, the tongue instantly darts forward and seizes the worms before they can escape. This is how the woodpecker feeds."

Lesson XII

More about Beaks

"Shall we finish our chat about the beaks of birds?" asked Fred.

"Oh yes, boys, do, please," said Norah. "I have been watching the ducks grope about in the mud with their broad flat bills, and I can't make out why they are always doing it."

"Well, we will talk about the duck's bill first, if you like," said Fred. "Teacher had a real duck's head to show us to-day. We took it in our hands and examined it for ourselves.

"The bill is, as you say, broad and flat, like a sort of shovel. It is not at all like any of the bills we have already examined. We found we could easily bend the mandibles in our fingers, for they are not hard. Such a bill therefore could not be meant for tearing flesh, for boring holes in trees, nor for stabbing its prey.

"We began to be very curious when teacher opened the mandibles and pointed out to us, along the edge of the upper one, a row of fifty or sixty projecting points. These form a sort of stiff fringe, something like the teeth of a comb. The tongue, which is large and fleshy, fills the whole of the mouth. All round the edge of the tongue there is a fringe, something like that which hangs from the mandible."

"How very strange," said Norah. "I can't think yet what the meaning of it all can be."

"When the mouth is shut," Fred went on, "the fringe on the edge of the tongue and that hanging down from the mandible fit into each other.

"These birds find their food by groping in the mud, with their shovel-like bills. The mud and dirty water are strained out at the sides of the mouth, but the insects, grubs, and worms, and whatever is fit for food are held back by the fringed edges as in a trap.

"You see, ducks live on grubs and worms, like the woodpecker, but they catch them in a different way.

"Geese and swans of course belong to the same class of birds."

"The nut-cracking birds have very curious beaks," said Willie. "Next time you see a parrot, Norah, have a good look at its beak. It is a short, strong, hooked bill, with a sharp point.

"These birds and others of the same class live on nuts, fruits, and berries, and they use their strong bills as their nut-crackers."

"Most of our small birds live on seeds, don't they?" asked Norah.

"Yes, and we might put them all in one class and call them seed-eating birds," said Fred. "The beak is short, hard, and strong, and shaped like a cone. They use these bills to crack the husks of the seeds."

"Oh yes," said Norah, "I have often watched our canary crack his seeds and drop the husks on the floor of the cage."

Lesson XIII

Vapor—What becomes of It

"Our last chat about vapor," said Fred, "showed us that evaporation is constantly going on everywhere. The air always contains vapor, and yet we cannot always see it. Teacher proved this in a very simple way to-day. How do you think he did it? He stood a tumbler of cold water on the table."

"Please tell me all about it, Fred," said Norah, "for I can't see how that would prove it."

"Well," said Fred, "after he had let the tumbler of water stand some time on the table, he showed us that the outside of the glass was covered with tiny drops of moisture.

"This moisture did not come from the water in the glass. It came from the vapor in the air. That vapor was at first invisible, but when it touched the cold sides of the glass, it became visible as little round drops of water, which settled on the glass itself."

"We could not at first make it out," said Willie, "for teacher had a tumbler of warm water on the table as well as the other one; and there were no drops of moisture on this."

"Let me see," said Fred, "whether I can

explain it. Take this slate, Norah, and breathe on it. I cannot see your breath; but look at the slate, and you will see some drops of moisture on it.

"Now hold the slate over the spout of the kettle, while the steam is pouring out. What do you see? The slate is covered with little drops of moisture.

"The vapor in the air leaves little drops of moisture on the sides of the tumbler; the vapor from your breath and the steam from the kettle leave drops of moisture on the slate. The tumbler and the slate were cold.

"It is cold that changes the vapor into drops of moisture. Teacher says the vapor in the air is invisible only because it is split up into such extremely small particles that they cannot be seen.

"Cold causes these tiny particles to rush together, so that they are pressed into a smaller space, and then we can see them. We say they are condensed.

"The steam as it first comes from the spout of the kettle is invisible. But when it meets with the colder air of the room it condenses. The tiny particles of the vapor are made to rush together, and we see it as it floats away.

"We do not usually see our breath as it leaves the mouth and nostrils. But when the weather is very cold, the vapor of the breath condenses and the breath at once becomes visible."

Lesson XIV

Clouds, Rain, Dew

"I little thought," said Willie, "when we started our chats about vapor, how far they would lead us. Why, that tumbler of cold water has told us all about the dew-drops we see on the grass in the morning; the steam from the spout of the kettle explains the clouds that we see in the sky, and——"

"You forget, Will," said Norah, joining in, "you have not yet explained all this to me. I want to know, please."

"Well, then," said Will, "suppose I try to explain it to you now. You know that evaporation is always going on around us from the surface of the earth, from seas and rivers, and from plants and the bodies of animals.

"We do not see the vapor in the usual way. But sometimes the air, instead of being transparent and allowing us to see through it, is thick and opaque. The vapor in the air has been condensed, because the air around is cold. This condensed vapor is called fog.

"When the air all round is not cold, the vapor rises and floats away over our heads, and we do not see it till it meets with the cold air above. This cold air condenses the vapor and forms a cloud."

"Then a fog and a cloud must be very much the same thing," said Norah, "except that the cloud is high up in the sky and the fog low down near the ground."

"Yes, they are," said Willie. "People who travel over mountains often find themselves in the midst of a dense cloud, and they walk through it just as we walk through a fog."

"I know now what clouds are," said Norah. "Often when we look up at the sky we can see clouds; but I can't quite understand yet why the clouds send us rain."

"I think I can explain that," said Willie. "The clouds consist of vapor condensed into little particles which are just able to float in the air. If a cloud passes through still colder air, the vapor will condense still more, and the little particles will rush together, and form actual drops of water too heavy to float in the air. Then they must fall to the earth as rain.

"Sometimes the drops are very small indeed, although too heavy for the air to hold. They fall as extremely fine rain, which we call mist."

"You have not yet explained the dew on

the grass," said Norah, "although you said the tumbler of cold water told you all about it."

"This is the way teacher explains that to us," said Willie. "He says that often after a warm day the air near the earth becomes suddenly cold at night. The evaporation is still going on rapidly, but as the vapor is formed it is condensed on the cold surface of the ground, the grass, and the leaves of plants, just as the vapor in the room condensed on the cold tumbler. This forms drops of dew."

Lesson XV

Birds—Their Legs and Feet

"We had another lesson about birds to-day, Norah," said Fred, "and we are beginning to learn how to arrange all birds in classes. As in the case of other animals, the feet have as much to do with it as the head. We have been comparing the feet of birds to-day.

"Teacher commenced by showing us a picture of a large powerful leg and claw. The claw has three strongly-jointed toes in front and one behind, and each toe is armed with a long, sharp, hooked talon.

"He then showed us the picture of the heads of birds, and asked us which head would best suit such a claw as this.

"Of course we had no trouble in telling him. The claw belonged to one of the birds of prey. These are just the sort of feet we should have

expected to find in a bird with such a cruel, fierce-looking head and beak.

"Birds of this class pounce down suddenly with great force upon their prey, burying the sharp, hooked talons deep in the flesh. They then raise themselves with their powerful wings and bear off their victim to their nest to devour it, tearing it to pieces with beak and talons.

"We called them the lions and tigers of the air. They are also called seizers, and now you know the reason for this name."

"Look at the canary, Norah," said Willie, who wanted to have a turn now, "he is asleep on his perch. Don't you sometimes wonder how he can manage to sleep there without falling? It has puzzled me many a time."

"Yes," said Norah, "it has puzzled me too. I should like to know all about it."

"Well," said Will, "the canary has the same kind of foot as we find in the sparrow, thrush, lark, robin, and the hosts of little birds to be met with in our woods and fields.

"The foot has three long slender, jointed toes in front and a short one behind.

"None of these birds walk well on the ground. They go with little short hops; they do not walk. Their long toes are made for grasping a twig, and not for walking on a flat surface. They live almost entirely in the trees, where they are quite at home hopping from twig to twig.

"They sit or perch on the branch, and are called perchers. They even sleep like this, and could not fall from their perch if they wished."

"How strange," said Norah. "Go on, Will, please."

"Teacher showed us the leg and foot of a fowl. He pointed out a flat white cord that runs up the leg from the foot. When he pulled the cord the toes closed up, and when he let go, the toes stretched themselves out again.

"He told us that all birds have this same strong cord up the leg. But in these perching birds the cord passes up the leg and over the front of the knee-joint, to the thick part of the thigh. The very act of sitting must of course bend the knee, and this pulls up the cord, and so draws the toes together without any effort of the bird itself.

"The mere weight of the body resting on the legs does it all. The moment the knee bends, the toes draw themselves up to clasp the branch, and they cannot unclasp it until the bird raises itself from its perching position."

"Thank you, Will," said Norah. "That is certainly very wonderful."

Lesson XVI

Birds—More about Legs and Feet

"You remember our talk about the woodpecker, Norah?" said Fred.

"Oh yes," said Norah. "He lives on worms and grubs which eat their way into the woody stems of the trees. He has a wonderful beak for boring into the trees, and a wonderful tongue for catching his prey when he has found out where they are."

"Quite right," replied Fred. "Now try and remember something more. These birds live entirely in the trees because their food is in the trees, and in the trees they are extremely nimble. You would be surprised if you could see one of them run up the rough bark of a tree.

"Teacher showed us a picture of the woodpecker's foot. It has two toes in front and two behind. Birds with such feet are never seen on the ground. They could only hobble about in a painful, awkward way on a flat surface. But they can run up the rough bark of trees, or climb about the branches with the greatest ease. We call the woodpecker a climbing bird,

and the parrot is another member of the same class.

"Both birds, you see, live in the trees, and find their food in the trees, and both are fitted in every way for the life they have to lead.

"Suppose we go and look at the fowls in the garden now. There they are scratching about on the ash-heap. What a mess they are making! Do you know why they are scratching? They are searching for grubs and worms and whatever they can find.

"Let us look at their feet. The toes, you see, are short and thick and armed with strong

blunt claws. The legs too look strong, as if they were meant for hard work.

"Teacher says these legs and feet are given them for scratching in the ground in search of food. Birds of this kind are called scratchers.

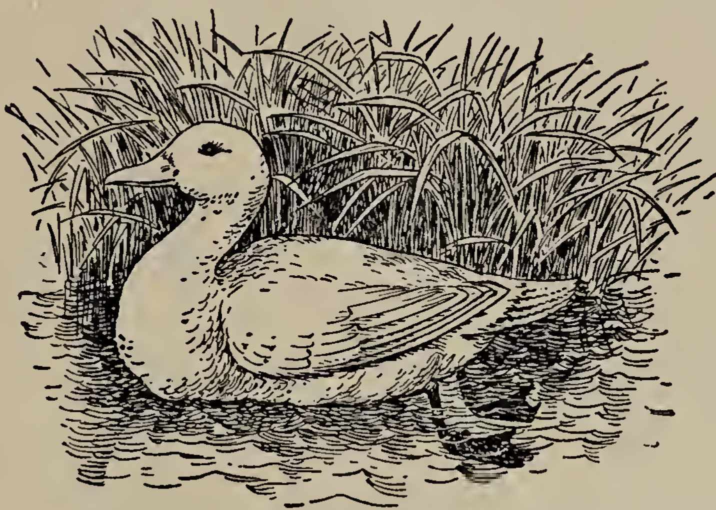
"Fowls, pigeons, turkeys, pheasants, and partridges all find their food by scratching in the ground. They are all scratchers."

"Teacher showed us a picture," said Will, "of a bird with extremely long, slender legs and feet. The legs are so long that the bird looks as if it were on stilts. Teacher pointed out to us the long, sharp, pointed bill, and we saw at once that this must be one of the fishing birds. The sharp bill is meant to catch fish.

"These birds always live near the water. Indeed, they walk or wade in the water in search of their prey. We call them waders. Their long stilt-like legs are for this very purpose, and their long necks are to enable them to strike at their prey in the water.

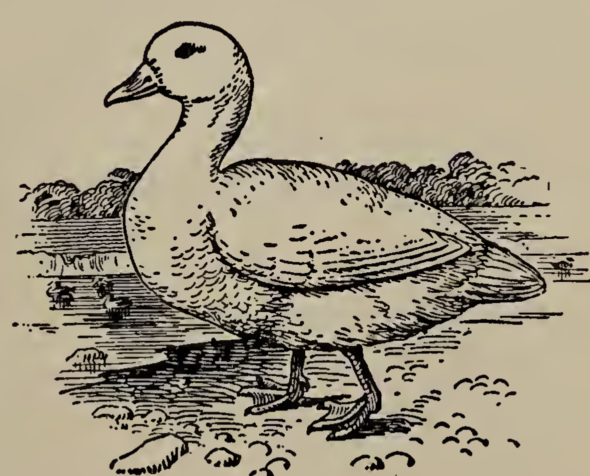
"The heron, crane, stork, and flamingo are all waders."

"There are, besides the waders, some other birds that live in and near the water," said Fred. "These, however, don't walk in the water, they swim. They are made to swim. Do you know what birds I mean, Norah?"



"You must mean ducks and geese and swans," said Norah, "for I have seen them swimming in the lake in the park."

"Let me tell you how it is these birds are able to swim so well," said Fred. "If you look at the duck's foot you will see there is a skin or web stretched between the toes. We call it a webbed foot. The webbed feet enable these birds to swim. They are the swimming birds. They swim in the water, and with their shovel-like bills they find their food in the water."



"There are some birds, Norah," said Will, "that neither perch on the branches nor climb trees; that neither wade in the water nor swim. In fact, they do not even fly. They can only run. We call them runners. They are great birds.

"The largest of them, the ostrich, is often seven feet high. They all have powerful legs for running, but as they do not fly, they have no use for wings. The wings are always very small. The foot has only two short thick toes. It is meant to be a solid support for the runner."

Lesson XVII

Solid Water

"Look what I have got to show you?" said Fred, as he came in from school.

"Why, it is a lump of ice," said Norah. "What are you going to do with that, Fred?"

"I am going to try and teach you something about the ice, as teacher taught us in our lesson this morning. I'm going to be teacher to-night," said Fred.

"But where did you get the ice?" asked his sister. "You couldn't get it out of the ponds. The weather is not cold enough."

"What has the cold to do with it?" asked Fred.

"It is the cold that changes the water into ice."

"Quite right," said Fred. "This ice is now a solid body. It is solid water. It was once liquid, like all other water. Ice and water are the same substance in different forms. I asked Mr. Mabbs, the fishdealer, to give me this piece of ice on my way home.

"Can you tell me any other substances you have seen in both the solid and liquid form?"

"Oh yes," she replied. "I've seen butter and dripping, wax and sugar, sulphur and lead in both forms."

"How can we change a piece of butter into the liquid form?"

"We must heat it."

"How do we describe the change that takes place in the butter?"

"We say the butter melts."

"Teacher melted several substances during the lesson by heating them," Fred added. "But while he was melting them he gave a boy the piece of ice to hold in his hand. When he asked the boy for the ice he found it was all gone."

"Of course," said Norah, "the heat of the hand melted the ice."

"Quite true; but would the other substances have melted in the same way?"

"Butter would have melted in the hand, but the wax, sugar, sulphur, and lead would not have melted."

"Why not?" asked Fred again.

"These substances require more heat than ice requires before they melt," said Norah.

"Now, I want you to think about some of the things you have seen melted," said Fred. "What happens to them all if we stand them aside in the liquid form for a time?"

"They all become solid again," replied Norah.

"We proved that by melting the wax and the lead in the spoon. When they were taken away from the heat they became solid once more."

"Notice how easily the piece of ice melts in front of the fire. I will catch the water as it drops from it in this saucer. Now if we stand this water aside, will it turn into ice again?"

"It will not turn into ice again here," said Norah. "It is not cold enough. But if we could put it into a very cold place it would become solid ice again. We should say that the water had frozen."

Lesson XVIII

Ice, Hail, and Snow

"I think we can find something more to say about ice," said Fred. "I seem to have learned ever so much from our last lesson.

"Just you try and think about the frozen ponds in winter time, Norah. Where do we find the ice?"

"It covers the whole surface of the pond."

"But suppose we took a hammer and broke the ice on the surface. Should we find the whole of the water in the pond solid ice?"

"No, the water is not frozen underneath."

"Can you tell me what would become of the pieces of ice as we broke them up?"

"They would float on the water."

"You are quite right. Teacher put a piece of ice in the water and we saw it float on the top. But what does that prove?"

"It proves that the ice is lighter than the water," said Norah. "If it were heavier it would sink to the bottom."

"Yes," said Fred, "ice is lighter than water, and it always forms on the surface. Even in a hard frost there is only a sheet of ice covering the surface of the water, and when it breaks up we can see the water below.

"Suppose for a moment that the ice were heavier than the water. It would sink to the bottom as it formed, and the whole pond would in time be solid ice. What would become then of the fishes and other creatures that live in the water?"

"Why, I suppose they would be frozen too, and die?" said Norah.

"Quite right," said Fred. "As it is, the ice protects the water from the cold. Without it the fishes and water plants would all die."

"I was very much surprised to learn about the hail and snow," said Willie.

"All right, Will," said Fred. "Then suppose you have a turn, and tell us all you can remember about them."

"Well, Norah, I suppose you know what the hailstones are like?" said Willie.

"They are like little round balls of ice."

"But what do you think they really are?" he asked again. "They are nothing more than frozen rain-drops. You know the rain falls in little round drops.

"Teacher says that sometimes the rain-drops, as they fall, have to pass through very cold air, and they are frozen into round balls of ice before they can reach the earth. The little round balls of solid water we call hail.

"Snow, too, is another form of solid water. You know that evaporation is constantly going on everywhere. The vapor as it forms rises and makes clouds. The clouds we see in the sky are only masses of vapor.

"Teacher says that sometimes the whole cloud of vapor becomes suddenly cold, and the tiny particles of vapor are frozen. This frozen vapor is too heavy to float in the air. It falls to the earth as snow."

Lesson XIX

A Snake

"I wish Norah could have been in our class to-day, Will, don't you?" said Fred. "I want to tell her all about our lesson, but I don't think we could make her understand these animals without pictures of them. I wish we had some of the pictures that teacher showed us at school."

Just then his father came in with something under his arm. "Look, children," said he, "what I have got for you. I have been very pleased to see you take so much interest in your lessons, and I have bought you this beautiful book of Natural History. It is full of pictures of animals, and I am sure it will be very useful to you."

How they shouted, and clapped their hands, and kissed their good kind father! It was really a sight worth seeing.

"You are a dear good father," said Fred, while the tears sparkled in his eyes. "This is the very thing we wanted. Now we can get along beautifully."

"Go on then," said his father, "and as I have a little time to spare, I will sit and listen to you."

Fred began by turning to some of the pictures of snakes. He pointed out the strange form of this new kind of animal—a creature with a very long body, but without the least sign of legs or limbs of any sort.

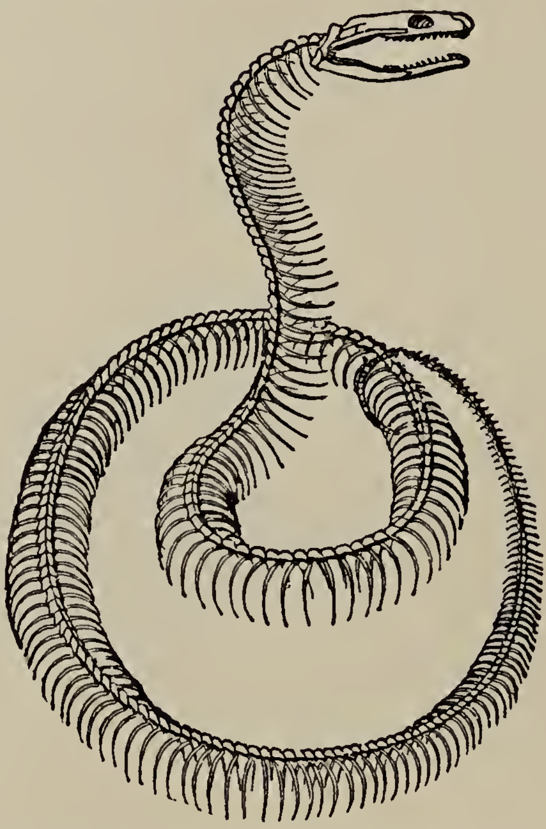
"But you must not think," he added, "that these are sluggish, helpless animals, because they have no limbs. They are all very quick and nimble in their movements. They are equally at home on the ground or among the branches of

trees, for they climb trees and dart from branch to branch with the greatest rapidity."

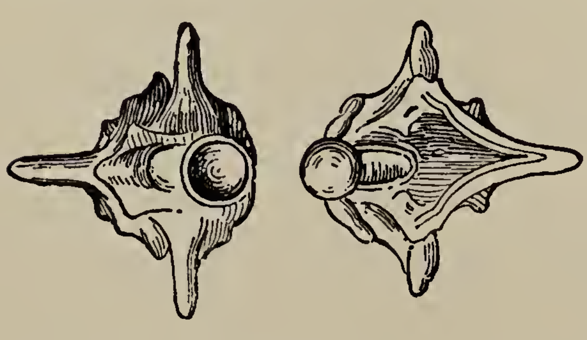
"But I can't see how they can move at all," said Norah, "without limbs. Other animals use their limbs for moving about."

"Teacher made us understand it all to-day," replied Fred, "and I think I can make it clear to you.

"Look at this picture. It is the skeleton of the snake. That great bone which runs through the whole length of the animal from head to tail is the backbone. Teacher showed us that this is not a good name, for it is really a string of separate bones; and they are joined loosely together in a very wonderful way.



"Each bone has a little round knob or ball in front, and a hollow cup or socket behind. The



cup of one ball fits into the socket of the next and forms what is known as a 'ball-and-socket' joint. Such a joint makes the body very flexible, and enables the creature to bend and twist easily in all directions.

"Now let us look at the short curved bones arranged in pairs on either side of the backbone. These are the ribs. I daresay you know that a man has a backbone and twelve pairs of ribs. Look what a number of ribs this snake has. Some snakes have as many as 300 pairs of ribs.

"Teacher next pointed out to us that these ribs are all jointed to the backbone by ball-and-socket joints, and that the lower end of each rib is free to move. They can move easily backwards, forwards, sideways—in every direction.

"We will next turn for a moment to the picture of the snake itself. The body, you see, is covered with scales, the one in front overlapping the one behind, so as to leave the hinder edge of all of them free.

"The scales are hard and horny, and those on the under part of the body are larger than the rest. These are joined to the lower ends of the ribs.

"Now, Norah, for your surprise. The snake moves about with these scales as if they were legs. The ribs can move in any direction. When the snake wishes to move, therefore, it advances its ribs. These carry with them the under scales. The scales take a firm hold of the ground or tree on which they rest, and the body is drawn forward with a gliding movement. Isn't that all very wonderful, sister?"

Lesson XX

How the Snake Feeds

"Shall we have another look at the snakes, Norah?" asked Fred.

"Oh do, please," said his sister. "I'll go and bring your new book."

"Well then," began Fred, as soon as they were seated, "suppose we talk about their habits of feeding. Snakes are as curious in their feeding as in everything else.

"They all live on animals. Some of the smaller snakes prey upon frogs, mice, rabbits, and other creatures they find on the ground. Some live almost entirely in the trees, and feed upon squirrels, birds, and even monkeys. But they all feed in one way.

"Animals like the cat, the dog, and the mole also live on flesh.

"How could we find this out for ourselves, if we did not know?"

"We should examine the teeth of the animals," said Norah. "That would tell us."

"Ah, but the strangest part of the snake is," said Fred, "that it has no long canine teeth for tearing flesh, and no sharp jagged teeth for cutting it through. The flesh-eaters have, but the snake has not. Snakes are not flesh-eaters."

"Why, I thought you just now told me," said Norah, "that all snakes feed on flesh."

"Yes, dear," said Fred, "so I did. But snakes do not eat their prey as the flesh-eaters do. They swallow them whole."

"Oh, how very dreadful," said Norah.

"Let us look again at the skeleton of the snake," said Fred. "The teeth, you see, in both jaws are small and sharp-pointed, and they all bend backwards towards the throat.

"Such teeth would be useless for tearing flesh or for chewing purposes. They are meant to hold the victim fast between the jaws while it is being drawn down the throat.

"But the most wonderful thing of all seems to be, that even the bones of the snake are made to help in the work of swallowing. Every bone of the head—the upper jaw as well as the lower—is movable. They are all jointed by ball-and-socket joints, and can be easily pushed out of their places. You know that the separate bones of the back, and the ribs which join them, are all arranged on the same plan, with ball-and-socket joints.

"Try to imagine a snake in the act of swallowing its prey. It takes a firm hold with the pointed teeth of one jaw, and draws its victim in, and then proceeds to take a fresh hold with the teeth of the other jaw. This action is repeated again and again, till the animal disappears down its throat, the bones of head, mouth, and throat all the time moving out of their sockets to make room.

"After the animal is swallowed, the ribs and the bones of the back move aside in the same way, to give more space for it in the stomach. Even the overlapping outer scales of the body do their part. They readily slip aside to make more room, as the body of the snake expands with its meal.

"It is clear therefore that the snake swallows its prey whole, because every part of its body was meant for this kind of feeding."

Lesson XXI

Mercury

"We have had a lesson to-day on a new substance, Norah," said Fred. "It is a metal; but it is not solid, like iron, copper, lead, or any of those which we have talked about before. It is a liquid.

"Teacher showed us some of it in a bottle. It flows about, and can be poured out like water. It is a liquid metal. It is the only liquid metal that exists. Its name is mercury."

"I think I have some mercury in a bottle upstairs," said his father. "I will go and bring it down for you; only be very careful with it."

Presently back father came with the bottle of mercury, and they were soon ready to start.

Fred poured some of it into a saucer, and pointed out its silvery white color and its bright metallic lustre.

"Teacher says mercury never tarnishes when it is exposed to the air, but always keeps its bright surface," said he.

"Now look what happens when I let fall a drop of the mercury on this slate. It breaks up at once into an immense number of tiny round drops. If I tilt the slate ever so slightly, the little drops run about rapidly over the slate."

"Then I suppose that is the reason why it is sometimes called quicksilver," said Norah.

"Yes, you are quite right," said Fred.

"Now, you shall take a saucer in each hand, while I pour the liquid metal into one and water into the other. What do you notice?"

"I am surprised to find the mercury so heavy," said she.

"Yes," said Fred, "it is heavy. It is heavier than any of the metals we have seen, except gold. Teacher says it is nearly fourteen times as heavy as water; gold is nineteen times as heavy as water.

"Can you tell me a property which all metals have?"

"All the metals are fusible," said Norah; "they all melt with heat, although they do not require the same amount of heat."

"Gold, silver, copper, iron, and steel are all fusible," said Will, "but they require intense heat before they will become liquid. Lead and tin we can melt for ourselves over the fire. They are more easily fused than any of those metals."

"Quite right," said Fred. "But mercury, you see, is a metal—the only metal, which is always melted, always in the liquid form, in this country.

"Remember, however, that in some very cold parts of the world mercury always becomes solid in the winter. In its solid state it is malleable, and can be beaten and rolled out like other metals."

"I thought it was very curious to see teacher boil the mercury in the tube, as if it were water," said Will. "We saw the liquid metal boil, and we saw the vapor from it condense into tiny little silvery balls, on the cool sides of the tube."

Lesson XXII

The Poisonous Snakes

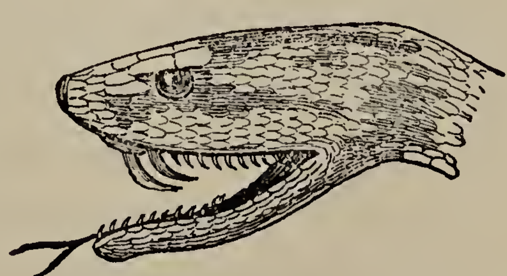
"I see you have your Natural History book under your arm, Fred," said Norah. "Have you got something more to tell us about animals?"

"We have had another lesson about snakes to-day," said Will, "so I suppose Fred wants to have a chat about them now."

The three were soon seated round the table, and then Fred began.

"Teacher explained to us that there are two kinds of snakes, which we may call the poisonous and the non-poisonous snakes. Suppose we talk about the poisonous snakes first. Here is a picture of one of them.

"If you look at it you will see, in front of the upper jaw, two long, curved, sharp-pointed teeth. These we call the fangs. We cannot see them when the mouth is



shut, for these teeth are movable, and they are then drawn up, and lodged in the gum.

"We sometimes call them poison fangs; but this is not quite correct, for there is no poison in the fangs themselves. Teacher showed us that the poison comes from two bags lodged in the back part of the mouth.

"The fangs themselves are really hollow tubes, and when the snake is about to dart at its victim, not only do the fangs show themselves, but the hollow tubes inside are filled with poison, which the poison-bags pour into them for use.

"These snakes always approach their victim with a stealthy, gliding, noiseless movement, until within striking distance. Then they suddenly dart forward like lightning, and one bite with those fangs is quite enough.

"The sharp teeth not only make a wound, but at the same time they leave some of the poison in the wound, and that soon kills the victim, or makes it insensible, so that the snake may gorge it at its leisure.

"Now I want you to look at the snake in the picture once more. Notice the long forked tongue. If you could see the animal alive, its tongue is never still. It is always on the move. It is the snake's feeler.

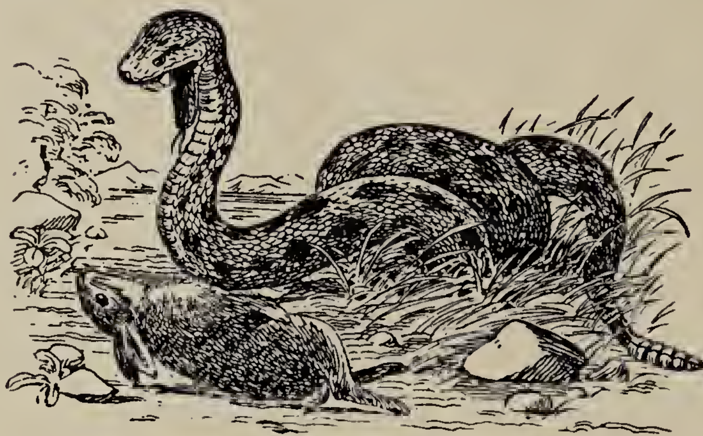
"It is a curious thing that some people have thought this restless tongue to be poisonous. This is not true; the tongue is quite harmless. The poison comes only from the bite of the fangs."

"I am very glad," said Norah, "that there are so few poisonous snakes in the world."

"Ah," said Will, "but you are not quite right, Norah. We have a number of poisonous snakes in this country, chief among them are the moccasin, copperhead, and rattlesnake. The moccasin and copperhead are much more dangerous than the rattlesnake, for they strike whom they meet without warning, while the whiz of the rattlesnake tells he is waiting.

"There are poisonous snakes in some countries much larger and much more to be feared than ours," he continued. "In India and Africa are poisonous snakes known as vipers, which can raise up and spread out the forward part of the body into a broad disk. The spectacled viper or cobra of India is one of these. It has a black line resembling a pair of spectacles about the broad portion of its disk. From this snake the jugglers of India draw out the fangs and then teach it to dance. The asp of Egypt is also a viper which has been noted in history. By pressing this snake on the nape of the neck the jugglers of Egypt used to throw it in an immovable position, which they called turning it into a rod.

"Here is a picture of one of our rattlesnakes. It gets its name from a sort of rattle which it has at the end of its tail. The rattle is formed



of a number of loose bones, which it shakes when it is angry."

Lesson XXIII

The Non-Poisonous Snakes

"I have been trying to think, Fred, which are the most terrible creatures, the poisonous snakes or the others," said Will, "and I can't make up my mind."

"No, Will, I daresay not," replied Fred; "they are both very dreadful."

"But," said Norah, "I should think no creature could be a more fearful enemy than one of those poisonous snakes. It has but to give a single bite with those awful fangs, and it is all over with its victim."

"Wait a moment, while I get my book," said

Fred. "There are some pictures of these non-poisonous snakes which I want you to see.

"This one is called the boa-constrictor, and this the python. They are huge serpents, and often reach as much as forty, fifty, and even sixty feet in length.

"If we could see within their mouths, we should find no long sharp fangs, and no poison-bags, for they do not kill their victims by biting them.

"Teacher says they coil themselves round the trunk of a tree, and lie in wait for some animal, perhaps a horse, an ox, or a deer.

"They give one awful spring as soon as their victim gets within reach, and coil and twist themselves round its body, with the suddenness of lightning. The poor creature at once finds itself entirely within the power of its enemy; it has no chance of escape.

"Their enormous strength enables these snakes to crush their prey within the folds of their long supple body, till flesh, bones, and all become a mangled mass. They then quietly uncoil themselves and settle down to gorge their meal.

"Like all other snakes, they swallow their prey whole, their scaly skin stretching till it almost bursts with the meal. They then creep away to some quiet spot and sleep till the pangs of hunger awaken them, and send them out to look for another victim."

"We have some non-poisonous snakes in this country," said Will, "but they are small and quite harmless. Here[1] is a picture of a common snake. Black snakes are non-poisonous, and, it may amuse you to know, they are the greatest enemies of the rattlesnake, with whom it is said they wage fierce battles. Then we have milk snakes, bull snakes, the common garden snake, which likes to sun itself under rose bushes and catch the insects attracted by the foliage. The black snake seeks high dry hills, and curls itself

[1] See p. 61.

upon boulders warmed by the summer sun. Most of the non-poisonous snakes seek the lower lands, however, and not uncommonly make their home in damp woods and in banks by the sides of ponds, where their favourite food, the frog, is to be found."

Lesson XXIV

Mercury—Its Preparation and Uses

"What I had already learnt about the liquid metal, mercury," said Will, "made me glad when teacher told us we were to have another lesson on it to-day. Our lesson has shown us how it is obtained, and some of the uses we make of the metal. Shall I try and tell you about it, Norah?"

"Yes," said Norah, "please tell me all you can remember."

"Well then," he began, "mercury, like most metals, is usually met with in the form of ore. This ore is known as cinnabar. It is dug out of deep mines in various parts of the world, and looks like a rough, hard, brown stone, with very little metallic lustre. It contains besides the metal, mercury, a large quantity of sulphur. The mercury and the sulphur must, of course, be separated. This is done in a curious way.

"The ore is first broken up into small pieces, and mixed with quicklime. It is then put into large retorts and heated. A retort, you know, is a closed vessel, with pipes leading from it."

"I think I can tell why this is done," said Norah. "The sulphur would soon melt into a liquid, and boil; and then it would pass away along the pipes in the form of vapor."

"That's just it," said Will. "But we have already learned that the mercury too would boil and pass away in vapor. This mercury vapor must not be lost. It is wanted.

"Some earthenware pipes are therefore fixed to the retorts, and the vapor is made to pass through them. As these pipes are kept cool, the vapor condenses on the sides in little round, silvery balls, and nothing more need be done than to collect them, and pour off the liquid metal ready for use.

"Suppose I tell you now," he continued, "some of the uses to which mercury is put.

"One of the most important uses is in separating gold and silver from the ores in which they are found.

"You remember that gold is usually found in small grains in the midst of certain rocks. The rock is crushed up very fine, and then mixed with mercury. It is a curious property of mercury that it will at once unite with other metals if it is mixed up with them.

"The mercury in this case seizes upon the little grains of gold, but will not unite with the earthy parts of the ore. The earthy parts are carefully washed away in shallow troughs, leaving the heavier metallic grains behind.

"These are easily collected, and all that remains is to heat them gently. The mercury flies off in vapor with the heat, and is condensed and collected for further use. The grains of gold remain behind.

"Mercury is also used for 'silvering' the backs of looking-glasses, and for various other purposes."

Lesson XXV

The Frog

"Come and see what we've got, Norah," said Fred.

"Oh, you dreadful boys," said Norah; "it's a nasty, ugly frog. I don't like frogs."

"But we had a fine lesson about the frog, Norah," said Will. "He's a poor, harmless, little creature; and I am sure you would like to know something about him, although I am bound to say he is not very handsome. See what you can find to tell her about him, Fred; and here, I've got your picture-book all ready."

"Well, just look at him as he sits there," said Fred. "His great, broad head, wide mouth, and goggle eyes seem exactly suited to his broad, squat, ungainly body; and I must say Norah is right. He certainly is ugly. At least I can't call him good-looking.

"Then, too, compare his long hind legs with

his little, short fore-legs. They look awkward as he sits there; but see, when I put him on the ground, what good use he makes of those strong, hind legs in leaping."

Norah gave a little scream as the frog leaped towards her; but the boys soon had him again safe enough.

"Look at his feet, Norah," said Fred. "The hind feet have five toes and are webbed. What does this tell us?"

"The animal is made to swim," said Norah. "I have often watched the frogs swimming; they seem quite at home in the water.

"Poor little thing," she added; "he sits quiet enough;" and then she thought she would venture to stroke him. But Mr. Frog was not used to these little attentions, and he leaped away.

She gave a shudder as her hand touched his cold, clammy body. In fact she had hardly got over her fright when Fred came back again with him in his hand. He told her that the frog's skin is always cold, and covered with a slimy fluid.

If a frog were put into a dry place, the skin would quickly shrink and become stiff, and the animal would die. The skin is very porous, and absorbs water like a sponge.

"Now," he added, "I think I had better tell you about the frog and his food. If we could see inside his mouth, we should find that the upper jaw contains a row of sharp pointed teeth, and there are no teeth in the lower jaw.

"But the tongue is more wonderful than the teeth. Instead of springing from the back of the mouth, as the tongues of most animals do, his tongue has its root in front, and points backward towards the throat. He can when he wishes throw the tongue forward a long way beyond the mouth.

"He preys on living insects—slugs, grubs, worms, and snails. He swallows his prey whole. The sharp teeth in the upper jaw are to help him to hold his slippery prey, while he swallows them. They are not meant for chewing or tearing.

"But his great tongue is his fly-trap. It is always covered with a thick, slimy fluid. As sure as a fly comes within reach, the slimy tongue darts forward like lightning, and never misses its prey."

Lesson XXVI

Air

"Norah, hand me the water-bottle, please," said Fred. "Be careful; it is full of water. Thank you. Now, if I poured the water out of the bottle, what would you say about the bottle then?"

"I should say the bottle would be empty," said Norah.

"Ah, that's just what I should have said till to-day," said Fred. "But it is not empty. Is it, Will?

"Teacher proved to us that the bottle is not empty," he added. "He had a bottle which looked to be empty, and he pressed it, mouth downwards, as far as he could, into a large bowl of water.

"While he held it there, he made us notice that the water would not enter very far into the mouth of the bottle. The water in the neck of the bottle was not so high as the water in the basin outside.

"He told us that if the basin were deep enough, we might press the bottle down ever so far, but it would not be possible to fill it with water."

"Yes, but he did fill it though at last," said Will. "He slanted the bottle on one side, and then there was a gurgling sound, and the water rushed in."

"What do you think made the gurgling sound, Norah?" asked Fred. "Watch, while I do it now with this bottle. As I slant the bottle in the basin of water, something seems to come bubbling up out of it through the water, and now we can see that the bottle is full of water.

"That something that bubbled up was air. It was the air in the empty bottle that prevented the water from rising to fill it. The water could not enter the bottle, because it was already full of something else, and that something else was air.

"This proves that air is an actual substance, although we cannot see it. It occupies all the space of the bottle, and so long as it is in the bottle, the other substance, water, cannot enter."

"But," said Willie, "there is just one other thing to remember about the bottle. The water did enter a little way into the neck of it when you pressed it down. That proves that you were able to press the air into a smaller space. Teacher says air is compressible.

"Then, too, when you left off pressing the bottle down, the air in it sprang back to its former bulk, and the water that had entered the neck was forced out again. This proves that air is elastic."

Lesson XXVII

More about the Frog

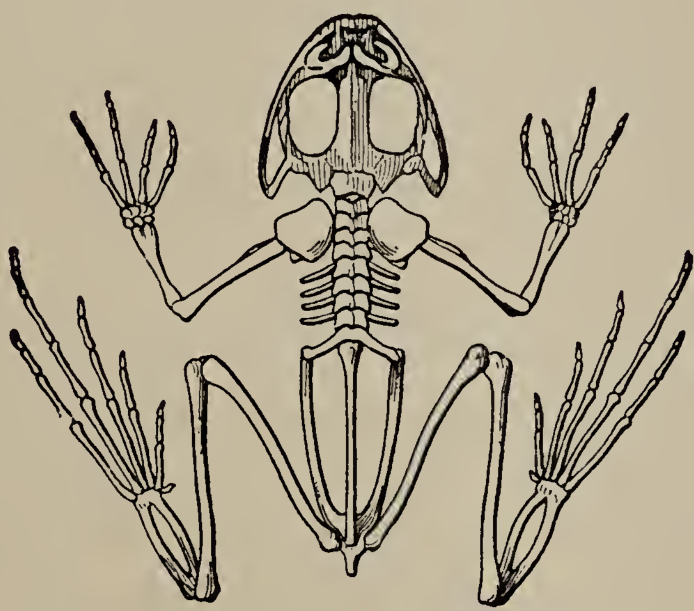
"Have you got over your dislike for the poor little frog, Norah?" asked Fred. "We have been learning some wonderful things about him to-day. Would you like to know how he breathes? It is all very strange."

"Yes," said Norah, "I should like to hear all about it."

"Well," said Fred, "before you can understand the breathing of the frog, I must make you think about the way in which we and most of the animals around us breathe.

"You can feel the ribs, which pass right round the upper part of your body. They form a sort of air-tight box, which we call the chest. The chest holds the lungs, and the lungs are the breathing organs.

"Our ribs are constantly rising and falling. You can feel them rise and fall, if you put your hand on your chest. When they rise



they make the chest larger, and the lungs inside expand; when they fall they make it smaller, and squeeze the lungs together again. As the lungs expand air rushes in at the mouth and nostrils to fill them, and when they are pressed together the air is driven out. All this goes on without any effort on our part, and this is the way we breathe. The great thing for us to remember is that the frog has no ribs, and cannot therefore breathe in this way.

"He must have air, however, and he is compelled to swallow it in gulps. He closes the mouth, and sucks up a quantity of air through the nostrils, swallowing each draught with a special effort. He cannot take in much air in this way, but he is assisted in breathing by his moist, porous skin, which also absorbs a small quantity of air.

"During the winter, when flies and grubs are not to be found, the frog betakes himself to the bottom of the pond, scoops out a hole for himself in the mud, and there sleeps till the frost and snow have gone.

"All this time his skin has to do the entire work of breathing by taking in air from the water, for the frog cannot breathe under water with his lungs any more than we could.

"Teacher showed us that, even with lungs and skin too, the frog takes in very little air, so little, indeed, that it is not enough to warm his blood. The blood is always cold. We call the frog a cold-blooded animal.

"This explains why the body is not provided with a warm coat, for there is no need to keep the heat in. It has nothing but a naked skin, which always feels cold and clammy to the touch."

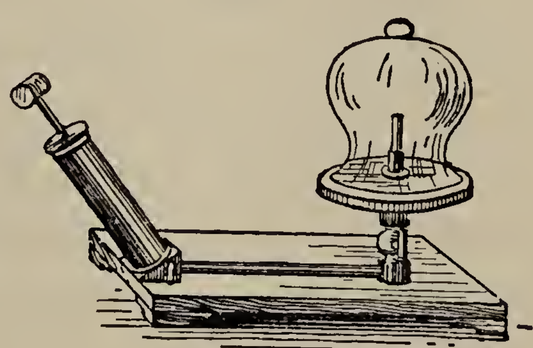
Lesson XXVIII

More about the Air

"You remember our talk about the water-bottle and the basin of water, Norah?" asked Fred. "What did we learn from it?"

"We learned that air is an actual substance, and that it takes up space although we cannot see it. The bottle was full of air, and that was why the water would not go in. When you slanted the bottle the air bubbled out, and the water went in."

"That's very good," said Fred; "and you must remember that there is air everywhere—in every nook and corner. What we call 'empty' is really 'full of air.'



"Teacher showed us a machine called an air-pump to-day. It will remove the air from a vessel and make it really 'empty.' He showed us too an 'empty' square box, a foot across each way, and of course it was full of air. He said that if he could pump all that air out, the box would weigh just an ounce less than it did at first. Can you tell me what that proves?"

"It proves that all the air in the box would weigh an ounce," said Norah.

"Yes, that's quite right," said Fred, "and so now you know that air, like every other substance, has weight.

"Now I want you to look carefully. I will fill this tumbler under the water, and then turn it upside down in the basin. The water stands in the tumbler, and does not run out into the basin. The reason is that the air in the room is pressing down on the water in the basin, and this prevents the water in the tumbler from flowing out.

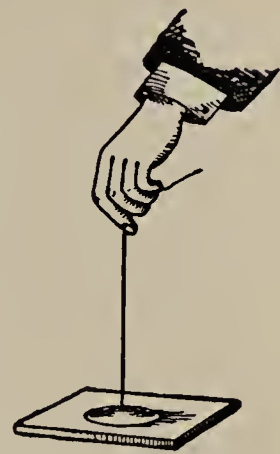
"We know then that air presses downwards.

"Teacher showed us another very clever thing. I've tried, but I can't do it yet. He filled the tumbler quite full of water, covered it with a piece of writing-paper, and then turned it upside down. When he took his hand away there was the paper, but the water did not run out of the glass.

"Teacher says the air in the room was pressing upwards against the paper. It must have pressed hard, for the whole weight of the water in the tumbler was resting on the paper, and yet it didn't fall out.

"This proves then that air presses upwards.

"Look now at my leather sucker. I make it hold to the stone, because I press out every particle of air between them. It holds because the air outside it is pressing it to the stone. If I try it on this slate, it does not matter whether I hold the slate level, place it against the wall, or sideways, the sucker will hold. The air in each case presses it against the slate.



"Now we know then that air presses with equal force upwards, downwards, sideways, and in all directions."

Lesson XXIX

The Frog and the Toad compared

"Fred, can you tell me the difference between frogs and toads?" asked Norah. "They seem to me to be so much alike that I am sure I could not tell one from the other."

"I think I can make it clear to you, Norah," said Fred. "We had a good lesson about these animals this morning.

"First, then, the toad is larger and more clumsily built than the frog. Its legs too are shorter, so that it cannot leap so far as the frog. The frog's hind legs are usually quite four inches long, and he leaps with these long legs. The toad's leap is only a very short jump. It is slow and awkward in its movements. The toad's feet are not webbed, so that it is not such a good swimmer as the frog. It lives mostly on land, and goes to the water only in the spring to lay its eggs."

"Then, too," said Will, "it is easy to tell a toad from a frog by the look of its skin. A frog has a smooth skin, but a toad's skin looks as if it were covered with thick warts or pimples. The frog's skin is either a greenish-yellow or brown above, and yellowish-white on the under parts. The general color of the toad's warty skin is a blackish-gray, with an olive-green tint. The under parts are yellow. Frogs and toads both have moist skins, but the toad can throw out over its skin a white liquid which has a most unpleasant smell."

"Many people used to say," said Fred, "that this liquid was a deadly poison, and because of that, no poor animal has been so cruelly treated as the toad. It is not poisonous; but it will make the tender skin smart if it touches it; and even a dog will quickly drop a toad if he takes one up in his mouth. I saw old Ponto do it once; and didn't he howl and shake himself."

"The frog has teeth in the upper jaw," said Will, "but the toad has no teeth at all. It has, however, a pair of well-grown ears, which the frog never has.

"The toad, like the frog, is a most useful animal in the garden. It preys upon grubs and vermin of all kinds — slugs, caterpillars, earwigs, beetles, worms — nothing comes amiss. Before winter approaches the toad leaves off eating, and hides itself away in a hole in the wall, or under a stone, where it lies torpid till the frost and snow are all gone."

"Do you know, Norah," asked Fred, "that the little newts, or efts, or effets, which we find sometimes in the ponds and ditches, are all animals of the same kind as the frog and the toad? The newts, however, have tails, which frogs and toads never have."

Lesson XXX

Gases

"I want you to think about the air again, Norah," said Fred.

"Oh yes," she cried, "we found out that air is an actual substance, which takes up space and has weight, like all other bodies."

"We have talked about solid bodies and liquids," Fred went on, "but air is a thin, light substance, which we cannot even see. It is not like either a solid or a liquid.

"Teacher says there are many substances that are like air and differ from both solids and liquids. He turned on the gas-burner to show us one of them. There was nothing to be seen, but we could hear something rushing out of the pipe, and we soon smelt it, and we saw it catch fire when teacher put a match to it."

"Oh, you mean the gas," said Norah.

"Yes, but its proper name is coal-gas, because it is made from coal," said Willie.

"All thin, light bodies like these," said Fred, "are called gases. Air is a gas, and the invisible vapor in the air is a gas—water-gas. Gases and liquids are alike in some things, but they differ in others.

"What happens when we turn on the faucet over the sink?"

"The water runs out," said Norah, "because liquids flow."

"Can you tell me then why the gas rushed out when teacher turned the burner on?"

"Well, I suppose it is because the gas flows along the pipes," said Norah.

"Quite right," said Fred, "it does; and so gases and liquids both flow."

"If you pick up the bellows and set them to work," said Will, "you will soon find that air flows; and you know, too, that the wind is only air rushing along."

"Teacher made a gas, called carbonic acid gas," said Fred. "We had to take his word that the gas was in the bottle, for we could not see it. But it was very funny to see him pour it out like water from one vessel into another."

"But I thought you said the gas was invisible," said Norah.

"So it is," replied Fred. "But teacher held a lighted taper between the two vessels, and told us to watch while he poured out the gas. This is a gas in which no flame could live, and although we could not see it flow from one vessel to the other, we saw it put out the light as it flowed.

"So then a gas is like a liquid, because they both flow.

"Now think again. We catch water as it flows from the faucet. Could teacher have caught the gas in a pail as it flowed from the burner? No; it would be impossible to catch the gas, because gases always spread themselves out rapidly in all directions. Teacher says gases differ from liquids in having no surface."

"Oh yes," said Norah, "and liquids always keep a level surface."

Lesson XXXI

The Frog—Its Life History

"Suppose my frog could talk, Norah, would you like him to tell you his history?"

"I should like it very much," said Norah.

"Then just shut your eyes and imagine me to be the frog. Listen to my story.

"'I have not much to thank my mother for. The first thing I remember was that I was a tiny thing, with a big head and a long, flat, waving tail. I found myself swimming about in the water. I had just come out of an egg, which my mother had laid in the water. In fact, that's all I know about my mother, for, as I told you, I never had a mother's care. People called me a tadpole.

"'Well, there I found myself, and I couldn't make out what I was. I was not a fish, although I had gills for breathing in the water, just as fishes have.

"'Presently I began to feel hungry, and it seemed quite natural for me to go to the water-plants and nibble off the soft shoots. I did

not wish for any other food, and my mouth seemed made on purpose for this; for it was placed not in front of my head, but under my chin, if you can make that out.

"'It was not a bad sort of life on the whole. I enjoyed myself very well, but I had to be always dodging the big hungry fishes, who wanted to make a meal of me.

" 'Well, this sort of thing went on for about six or eight weeks, when one day I began to be very frightened. I thought I must be growing deformed in some way, for I found two humps forming, one on each side of my tail.

" 'Day by day these humps grew, and presently two others began to show just behind my head.

" 'This was alarming, but it was nothing compared with my horror at finding that my beautiful waving tail was shrinking and wasting away by degrees.

" 'Day by day I swam about trying to make the best of it, when at last my tail went altogether. It dropped off.

" 'But by this time those humps at the sides of it had formed into a pair of beautiful long legs, and feet with webbed toes, just made for swimming. The other humps in front, too, had grown into another pair of legs, so that I found myself with four limbs, just as you see me now.

" 'My head and body had also grown larger and broader. Besides this, as my head took a more respectable, frog-like shape, my mouth became large and broad, and changed places to the front of my head, where it is now.

" 'Two things then happened. First I went quite off my appetite; that is to say, I couldn't eat those green shoots of the water-plants any longer. I seemed to have a craving for animal food.

"'At the same time I felt that I was being stifled. My gills had wasted away entirely, and now I could no longer breathe in the water. Something—I can't tell what it was—prompted me to leave the water, and as soon as I got on the bank by the pond, I found I could breathe air, for I had lungs instead of gills.

"'Just then a small beetle ran past me. I was only a very little fellow then, but I pounced upon it like lightning, and swallowed it in a moment.

"'I never felt so savage before; but I've made many a good meal since then on grubs, insects, worms, and slugs.

"'As I grew larger and larger my skin from time to time split, and I always tore it off with my paws, and swallowed it every bit. There was each time a new one underneath to fit me.'"

Lesson XXXII

Coal-Gas

"We have been learning more about coal-gas to-day, Norah," said Willie. "Let us call Fred in and have a chat about it."

Fred came in, and began by asking Norah to tell all she could remember about this gas.

"It is an invisible gas," she said. "It has a powerful and unpleasant smell, and it burns with a bright flame."

"You should have been with us in school," said Fred. "Teacher showed us another property of this coal-gas. He had a soda-water bottle, filled with a mixture of air and coal-gas."

"Oh yes," said Norah, "I remember. When the cork is pulled out and the light is brought near, the gas explodes with a great bang. You told me about it when we were talking about coal."

"So I did," said Fred. "I am glad you remember all about it. Teacher told us that sometimes people are careless, and leave one of the gas-burners turned on, so that the gas escapes into the room. Then we have all the materials ready for an explosion on a terrible scale. All that is wanted is a light.

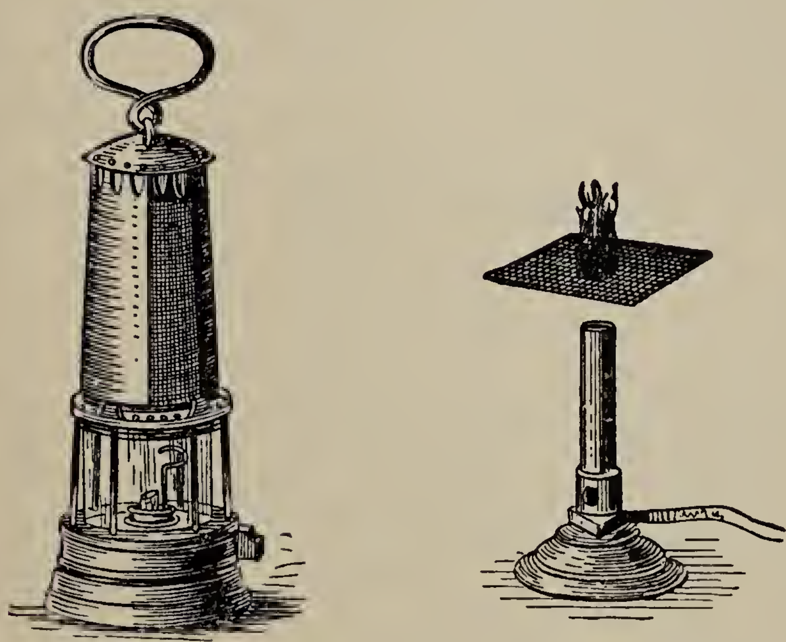
"You must never take a light into a room if you can smell gas. You are quite safe without a light, no matter how much gas has escaped.

"Go in, open the doors and windows, and the gas will soon pass away out of the room into the open air, and fresh air will take its place. Then, and not till then, will it be safe to get a light, and find out where the gas is escaping."

"You remember the fire-damp in the mine," said Willie.

"Oh yes," said Norah. "The coal gives off this gas in great quantities."

"Teacher says that this gas is really the same as the coal-gas we are speaking about; and



when it mixes with the air in the mine it becomes terribly explosive."

"I daresay you remember the Davy Lamp which the miners use," said Fred. "Teacher has got one, and he showed us what it is that makes it safe for burning in the mine.

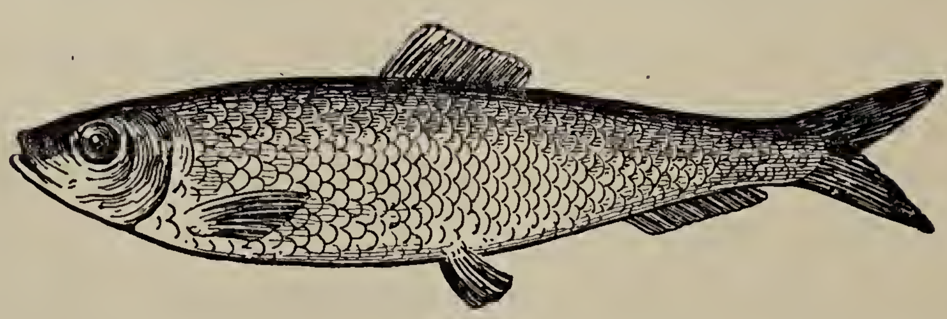
"He held a piece of wire gauze two or three inches above the gas-burner, and turned on the tap. Of course the gas passed up through the gauze. When he put a light near, the gas took fire above the gauze, but it did not burn at all below it.

"In the Davy Lamp, you know, the flame is shut in with this wire gauze. The explosive gas, if there is any in the mine, passes through into the lamp and burns round the flame, but the flame itself cannot pass out through the gauze, and so the air in the mine is safe from explosion."

Lesson XXXIII

A Fish

"You know, Norah," said Fred, "that a man, a dog, or a rabbit would die if held under water; and that a fish dies as soon as it is taken out of the water. But don't you think it is very strange



that both die from the same cause? They both suffocate. One cannot breathe in the water, the other cannot breathe out of it. Teacher has been helping us to understand how a fish can live and breathe in the water.

"He had a fresh herring for the lesson, and as mother has bought some for supper, I asked her to let me have one to show you.

"Here it is. Now look at these long slits, just behind the jaws. Lift up one of them, and inside you will see the red gills. The gills are the lungs of the fish, for fishes have no lungs such as we have. Fishes cannot live without breathing air any more than we can. We breathe by means of lungs, the fish by means of gills."

"But I can't see how a fish can breathe air," said Norah, "while it is living and moving about in the water."

"Ah," said Fred, "that is the wonderful part of it. You remember that water is porous, and that it absorbs air. Water, in fact, always contains air. The fish lives by robbing the water of some of the air, which it breathes in through its gills.

"If you notice a fish swimming in the water, you will see that it is constantly opening and shutting its mouth, as if it were drinking. It is not drinking. It takes the water into its mouth, but only to pass it backwards over the gills, and so out again through the slits at the sides.

"Teacher explained what all this means. He pointed out the redness of the gills; and he told us that, if our eyes were sharp enough, we should find these gills crowded with tiny blood-vessels. It is the blood in these vessels which gives the gills their red color.

"Every time the fish takes in water through its mouth, and pours it over the gills, the blood in the little vessels sucks up as much of the air as it can get from the water.

"This is the creature's way of breathing."

Lesson XXXIV

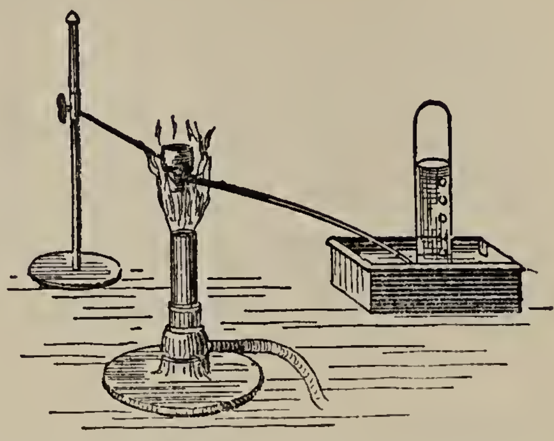
More about Coal-Gas

"Teacher made some coal-gas for us at school to-day, Norah," said Willie, "and it brought to my mind one of our very early lessons. Do you remember that we once made some gas in one of father's long clay pipes?"

"Yes, of course I do," said Norah, "and when you put a match to the stem of the pipe the gas burned there as it came out."

"Teacher made some gas in this way, only ever so much better than we could do it. Suppose we tell you all about it," said Will.

"Well," said Fred, "teacher had a long clay pipe filled with coal broken very fine, and closed up with clay just as we had. He fixed the bowl of the pipe over the flame of a gas-burner standing on the table. He turned the stem of the pipe so as to make the end of it dip into a bowl of water.



"He then filled a glass tube with water, and turned it upside down in the basin, taking care to keep the mouth of the tube below the surface of the water, and just over the end of the pipe stem. The water did not run out of the tube, but remained in it, while he held it there.

"Presently, as the bowl of the pipe got red-hot, the gas began to come out of the stem, and you should have seen what took place then. The gas rose through the water in little bubbles, and the bubbles ran up the tube one after another. As they ran up, the water began to flow out of the tube into the basin. In a little while it was all gone, and the tube was full of gas instead."

"Yes, and we knew it was really the coal-gas," said Will, "because when teacher took the tube out of the water and put a light to the mouth of it, it took fire and burned.

"Teacher says this is just the way the gas is made at the great gas-works.

"Instead of the bowl of the pipe with its pinch of coal-dust, they have large, strongly-built closed chambers called retorts, made of firebrick and iron, each one holding nearly a quarter of a ton of coal.

"Instead of the stem, they have long iron pipes; and instead of the little glass tube, they have enormous iron gas-holders, many times bigger than our school."

Lesson XXXV

More about the Fish

"I want you to think again about the fish and its breathing, Norah," said Fred. "It gets its air from the water. Now it is quite clear that it cannot get as much air in this way as lung-breathing animals can. We live and move about in an ocean of air itself. Now just tell me how you feel when Will and I give you a good long 'pepper' with your jumping-rope."

"I get out of breath and very hot; I breathe very rapidly," said Norah.

"That's quite right," said Fred. "You then breathe in more air than usual. Our bodies are always warmer or colder according to the amount of air we breathe in.

"Fishes take in so little air by their gill-breathing that it is not enough to warm their blood or their bodies. They are always cold. We call them cold-blooded animals."

"Teacher showed us," said Willie, joining in, "that this is why fishes are never clothed in wool, fur, or feathers, or even with a thick hide. They have no heat in their bodies to keep in; and they have no need of a thick warm coat."

"That's right, Will," said Fred. "I wanted to talk about their clothing next. Think of the herring and its shiny silvery-looking coat. But the coat kept coming off on my fingers while I was showing you the herring's gills, Norah."

"What do you mean, Fred?" asked Norah. "Do you mean those little round scales that you had all over your hands? Are they the herring's coat?"

"Yes, they are. Teacher says the fish is really encased in a coat of mail. Next time you see a fish, run your finger along its body from head to tail, and you will find it very smooth; then run it back again to the head, and the scales will ruffle up.

"Each scale is fixed into the skin in front only; the rest of the scale is loose and overlaps the next one behind it. As the fish moves through the water every scale is pressed closer and closer to its body, and there is nothing to hinder its movements."

"Why, that's almost exactly like the feathers on the bird's body," said Norah. "They all point backwards, so that the bird shall have nothing to hinder its flight through the air."

"That's a good girl," said Fred. "Now I will tell you one thing more about the coat of the fish. You know if you take a fish in your hand it feels slimy and slippery. Teacher says the fish sends out over its body a slimy oil, which helps it to glide smoothly and easily through the water."

Lesson XXXVI

Balloons

"I little thought," said Willie, "where teacher was going to lead us when he asked us to tell him all we could of the uses of coal-gas. Did you, Fred?"

"No, that I certainly didn't," said Fred. "It was easy to think of the use we make of it for lighting and heating purposes. But when teacher said he was going to talk to us about balloons, I began to wonder what balloons had to do with coal-gas."

"Why, of course," said Norah, "they can have nothing to do with it."

"Don't you be too sure, little girl," said Fred. "You had better wait a bit."

"Even then," said Will, "I couldn't make out how we were going to get any nearer to it with that cork and the basin of water."

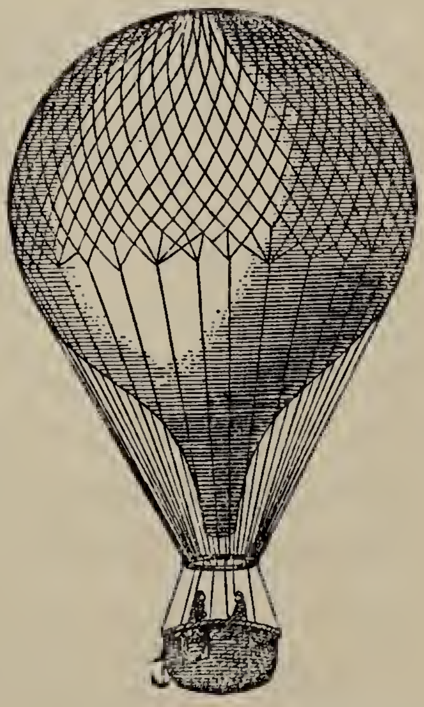
"Oh, do tell me all about it," said Norah. "I don't like puzzles."

"Well then," said Fred, "teacher held a cork at the bottom of the bowl of water, and then let go."

"Yes," said Norah, "and of course the cork rose to the top of the water."

"Ah, but why did it rise?" asked Fred. "Would a stone rise?"

"The cork rose," said Norah, "because it was lighter than the water; the water pushed it up. The stone is heavier than the water and sinks to the bottom."



"That was all teacher wanted us to see," said Fred, "and then he went back to the balloon. You remember seeing the men send the balloon up in the park last summer. It rose up through the air as easily as the cork rose through the water. What does that prove?"

"I suppose," said Norah, "it proves that the balloon is lighter than the air. But I can't see how that can be, for there was a car hanging from it, and there were two men in the car."

"Well, it certainly was lighter than the air," said Fred, "or it would never have risen and floated away as we saw it. Let us find out what made it light.

"That great silk bag which we call the balloon was filled with coal-gas, and coal-gas is only about half as heavy as air. When the great bag is full of this gas, therefore, it is not only able to rise in the air itself, but it is able also to carry up with it car and men too."

Lesson XXXVII

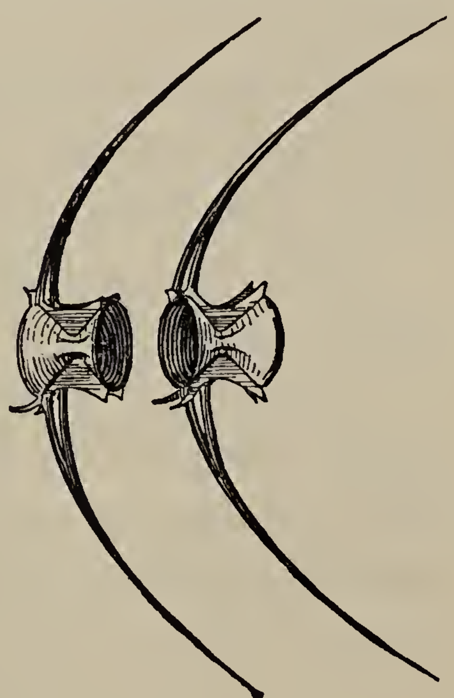
How the Fish Moves

"Teacher has been showing us to-day," said Fred, "how well the fish is fitted in every way for its life in the water. He showed us the herring again, and made us notice how the very shape of its body helps its movements. It is big in the middle and tapers to a sharp point both ways. It is just the shape to enable it to cleave its way through the water with the greatest ease."

"I remember the bird's body is built on much the same plan," said Norah, "and for the same purpose."

"He next showed us the backbone of a

herring, and broke the little bones in it apart to let us see how they are joined to each other. Each little bone has a hollow socket on both sides, and they are joined by the rim of one socket fitting closely to the rim of the next, so as to form a hollow ball between the two.



"I've got a backbone like it here. Look at it while I separate the bones, and you will understand it all. It is quite different from the backbone of the snake, the bird, or the rabbit. It makes the body of the fish very flexible; it can turn and twist easily in the water."

"Yes, but how does the fish move along?" asked Norah. "It has neither legs nor wings. It has no limbs of any sort."

"That's just what I am coming to next," said Fred. "If you look at a herring you will see several pairs of fins. First there is a pair, one on each breast, just behind the gills. These are the breast fins.

"Then there is another pair on the under part of the body—the belly fins. Teacher says these four answer to the four limbs of land animals.

"Besides these there is generally a large fin on the back, and one more under the body near the tail.[1]

"But the largest and most important of all is the broad upright fin at the end of the body. This is the caudal fin or tail fin."

"But why is this one the most important, Fred?" asked Norah.

"Well, it is this tail fin that really does the work of moving the fish through the water," said Fred. "The others are useful to balance the body and guide it as it moves."

Lesson XXXVIII

Tar

"You know, Norah, that if you watch a piece of coal burn, you will see some thick, yellow

[1] See p. 98.

smoke come from it, as well as the blaze," said Fred.

"Yes," said Will, "and it was just the same when teacher was making the gas for us in the tobacco pipe the other day. The first thing we saw was some of this same thick yellow smoke, which came puffing out from the stem."

"It seems very wonderful to me," said Fred, "how one lesson leads up to another. We have learned a great many new things to-day by only thinking over the lesson on gas-making.

"Just picture to yourself the great retorts in the gas-works. Not only gas, but dense masses of thick smoke are given off by the coal as it burns in them. The long pipes leading from them pass into great tanks of water.

"Everything, therefore, smoke as well as gas, must pass through the water.

"The gas is lighter than the water, and it bubbles up to the surface and is carried off, to be collected into the great gasometers. The water condenses the smoke, and it falls to the bottom of the tank as a thick black liquid.

"What do you think this is, Norah? It is tar. I had no idea what tar was till to-day. I am glad I know.

"Father has given me some tar in this old cup. Let us look at it. It is a thick, black, shiny, sticky liquid, something like molasses to look at. It has a powerful smell and a bitter taste.

"Look what happens if I put a drop of it on my hand. I cannot rub it off. I cannot wash it off. Some grease or turpentine will remove it, because tar is soluble in fat and turpentine, but it is insoluble in water.

"If I drop a little in this glass of water you will see that it sinks to the bottom. It will not mix with the water. It is heavier than the water. You know I told you that the people at the gas-works always find the tar at the bottom of the tank.

"Now watch while I dip this piece of stick in the tar and set light to it. It sends off dense clouds of smoke and blazes up in an instant. It is very inflammable.

"As you know this, I don't think it will surprise you to hear what I am now going to tell you. If tar is heated in a closed retort, some of it rises and passes away in the form of vapor.

"The vapor is carried along pipes into a cool chamber called a condenser. As it condenses it forms a new liquid, which is very highly inflammable, and is used for lighting purposes. It is called coal-naphtha.

"That which is left behind in the retort is the solid substance which we call pitch."

"What a wonderful substance coal is after all," said Norah.

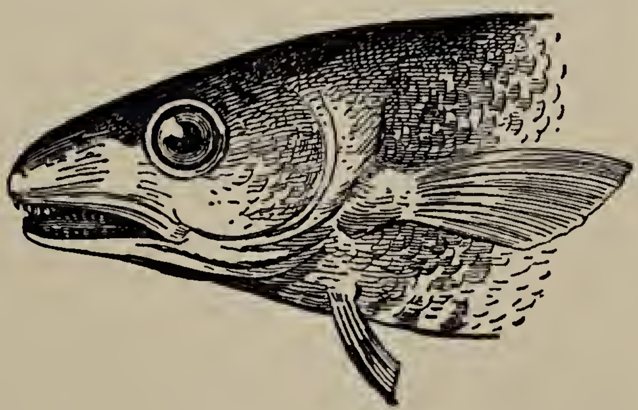
Lesson XXXIX

The Fish and its Food

"Isn't there something else you would like to learn about the fishes, Norah?" asked Fred.

"Well," said his sister, "I've been looking at the fishes in your picture-book, and I find that they all have small, sharp, pointed teeth in both jaws. There are a great many of them, but they don't seem to be meant either for tearing or chewing. I should like to know what food the fish feeds upon, and how it feeds."

"Then suppose we have a closer look at the teeth," said Fred. "The teeth are, as you say, simply little sharp spikes, but they all point backwards towards the throat. Where have we seen teeth like this before?"



"The snakes have teeth just like this," said Norah. "They feed upon animals, and swallow their prey whole."

"Fishes," said Fred, "feed on one another, and they too swallow their prey whole without waiting to chew it. They are very fierce and greedy, and from the largest to the smallest, prey upon and devour each other. They hunt their prey through the water as the lion, tiger, and other fierce flesh-eaters hunt theirs on the land."

"This explains," said Willie, "why they are made for easy and rapid movement through the water. At one time they are the hunters, at another they are the hunted prey."

"The backward pointed teeth are meant to seize the prey," said Fred. "They must be strong enough also to hold the struggling, slippery victim fast, while the work of swallowing goes on.

"There is just one other thought, Norah," Fred continued. "All fishes come from eggs. Next time you get a herring, open it and take out the roe. If it is a hard roe, you will see that it consists of an immense number of little grains or balls. Each of these is a tiny egg, and would have become a fish.

"I daresay you are thinking, 'What an immense number of eggs from one single fish!' So it is, but let me tell you that these eggs, after the spawning, are the favorite food of many water animals.

"Even the young fishes that come from the spawn of one kind feed on the eggs laid by others. Then, too, these same young fry, as the little baby fishes are called, form the chief food of all others that are large enough to prey upon them."

Lesson XL

Paraffin Oil

"Our lessons on coal-tar and naphtha, Fred, like a good many others, have led us farther than I thought they would," said Willie. "Who would have thought now that they had anything to do with paraffin oil?"

"Does paraffin oil come from coal-tar and naphtha then?" asked Norah.

"No," said Fred, "not exactly. But teacher has been showing us to-day that there are a great many inflammable liquids very much like the coal-naphtha in their properties. Some of them are prepared by man, but most of them are got direct from the ground.

"Petroleum or rock-oil is the commonest of these. It is obtained from springs in many parts of the world, but chiefly in America and Russia.

"Teacher says that these oil springs in some places rise to the surface of the ground; but as a rule deep wells are sunk, and the oil is pumped up from them.

"The petroleum as it comes from the earth is of a dirty greenish-yellow color and very thick and oily. In this state it is unfit for use. It is pumped from the wells into great tanks, whence it is sent along iron pipes to the refining factories to be purified.

"A coarse rough oil very like this is obtained from peat, from various kinds of coal, and, as we have seen, from coal-tar.

"In the refinery this coarse oil separates into a variety of different substances. There is first of all the clear liquid commonly called paraffin oil, for burning in lamps.

"That which is obtained from petroleum or rock-oil is called kerosene.

"Then, besides this, there is a beautiful, fine, white substance like wax, which is known as solid paraffin, and is largely used in making candles.

"Lastly, that which is left forms a rough coarser kind of oil, which is used for oiling machinery."

"Teacher explained to us how the paraffin oil burns in a lamp," said Willie. "The porous wick absorbs the oil, and the heat of the flame makes it evaporate. It is not the oil itself that burns, but the gas or vapor from it, just as the ordinary coal-gas burns in our gas-burners.

"Teacher showed us that the oil itself will not burn. He thrust a burning match into some of it in a saucer. The oil did not take fire. It actually put out the match.

"He told us that it is only when paraffin is allowed to get heated that there is any danger. When it is heated it gives off this gas, and the gas is very explosive when mixed with air.

"He showed us another liquid called benzine, which is obtained by refining the coal-tar naphtha. He poured a small spoonful of this into a saucer and put a light to it, and it blazed up in a moment with a little bang.

"He said it was the gas or vapor only in this case that exploded. But benzine is much more dangerous than paraffin, because it constantly evaporates with the heat of an ordinary warm day."

Lesson XLI

An Insect

"We had a lesson on insects to-day, Norah," said Willie, "and it was all new to us, and very wonderful. Fred has gone to find one or two insects now, so that we may have a talk about them. Here he comes; let us get ready for a chat."

"Look!" said Fred, as they sat down at the table, "I've got a beautiful butterfly, a beetle, and a fine big blue-bottle fly. They will do well. First of all, let us see why these little creatures are called insects.

"If you take any one of them in your hand, you will see that it appears to be deeply cut across in two places, so as to be almost separated into three distinct parts. This is why we call it an insect. The word insect means 'cut into.' The three parts are the head, the chest, and the belly.

"Look at it again carefully," he continued, "and you will see that the chest and belly parts are made up of hard horny rings. Teacher calls them ringed segments. A segment means a part. These segments are not complete rings, as they do not pass entirely round the body.

Each one is in two parts—an upper and an under half. The two parts are joined at the sides by a loose skin. In most insects there are three of these ringed segments in the chest and nine in the belly. They overlap one another, and give the body great freedom of movement.

"Teacher says the bodies of all insects are made up of ringed segments like these."

"Now, Fred," said Willie, "shall we have something about the head next?"

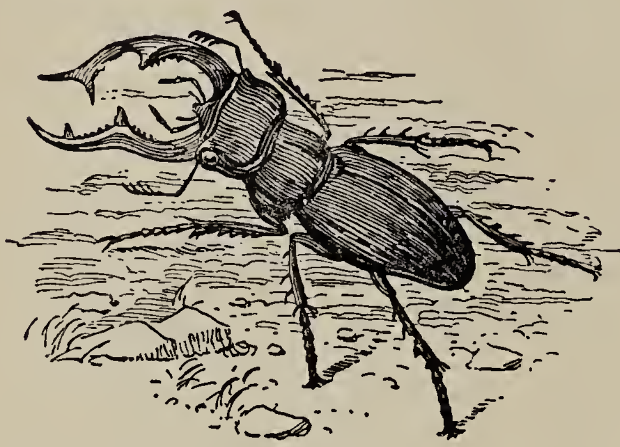
"Yes, Will," answered Fred, "suppose you tell us all about it."

"Well, first of all, the head is in one piece," said Willie. "It is not made up of ringed segments. There is no skull or brain case, because insects have no brains. Teacher says they have instead a number of knots of nerves in various parts of the body.

"The eyes are placed at the side of the head, not in front, so as to enable the insect to see around it in all directions. Teacher says they are most wonderful eyes, for each eye is really a close cluster of little eyes. Insects have many enemies. These sharp eyes are almost their only chance of escape.

"Oh, I was going to forget their feelers," he added. "You can see them, Norah, one on each side of the head. These are supposed to be organs of hearing and feeling. Now, Fred, can you think of anything else?"

"Well, we must not forget the mouth," said Fred. "In insects, as in other animals, the form of the mouth depends on the kind of food. The beetle has a pair of strong biting jaws or mandibles and another pair of chewing jaws, and so have all insects that live on solid animal or vegetable food. They bite off their food with their mandibles, and chew it with their chewing teeth.



"Other insects, such as the bee, the common house-fly, and the butterfly, live on juices, which they suck up through a trunk. They have no jaws.

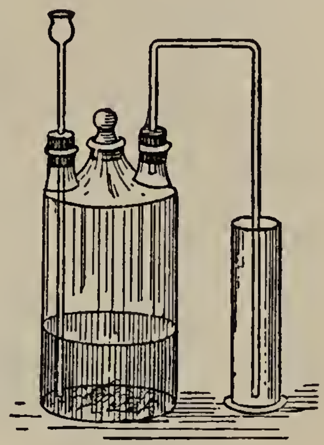
"Remember one thing. Whenever insects have jaws they always open sideways, and not up and down as ours do."

Lesson XLII

Carbonic Acid Gas

"We have from time to time heard about the gas called carbonic acid," said Fred. "Teacher made some for us to-day. I'll tell you how he did it, Norah.

"He put some small pieces of chalk into a bottle, which was fitted with a bent tube and a funnel. He poured enough water down the funnel to just cover the pieces of chalk, and then he added a little of a liquid which he called hydrochloric acid. All at once a bubbling commenced round the pieces of chalk, and the bubbles rose up and burst on the surface of the liquid. These were bubbles of the new gas, carbonic acid. They came from the chalk.



"The gas first filled the bottle, and then passed away down the tube into some gas jars, one by one, standing on the table."

"Then, I suppose," said Norah, "this is a gas that you can see?"

"No, it is an invisible gas," said Fred, "and we had to take teacher's word for it at first that he had filled the jars with the gas. It was no use to smell it even, for this gas is inodorous."

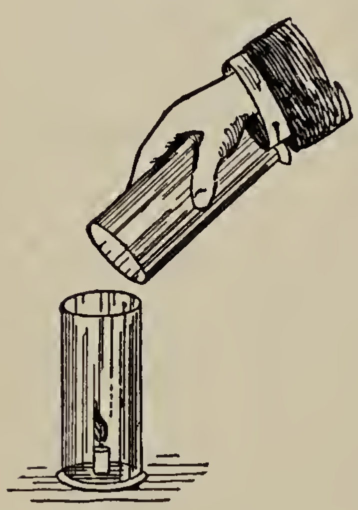
"It seemed very funny to me," said Willie, "when teacher simply dipped the end of the tube in the jar, and presently said the jar was full of gas."

"You see," said Fred, "this gas is heavier than air. If we had poured water into the jar, the water would have sunk to the bottom, and pushed the air out as it rose. This carbonic acid gas does just the same."

"But how did you know there was carbonic acid gas at all in those jars, Fred?" asked Norah.

"I'll tell you," said Fred. "Teacher took one of the jars, and poured into it some clear lime-water."

"Oh yes, I know," said Norah. "The lime-water turned white and milky-looking."



"It did," said Fred, "and that proved the gas to be carbonic acid.

"He next plunged a burning taper into one of the other jars, and it went out instantly. Then he put a piece of lighted candle in the bottom of an empty jar (I mean a jar containing nothing but air). We could not think what was coming next, but he took the other jar of carbonic acid gas, and poured it, as you would pour water, on the burning candle.

"The gas at once put out the light. Carbonic acid always does this. We now knew from the lime-water and the burning candle that the gas was carbonic acid."

"But teacher made this gas in two other

ways," said Willie. "He put a piece of burning candle in a bottle and closed the mouth. The candle burned for a little while, and then died out. When he tried the lime-water test, the gas in the bottle proved to be carbonic acid.

"We now know that burning of every sort always produces this same carbonic acid gas."

"I think," added Fred, "you have seen me breathe into a tumbler of lime-water, and turn the water white and milky-looking? That proves that carbonic acid is given off with my breath. Teacher says that not only we, but all animals breathe out carbonic acid gas."

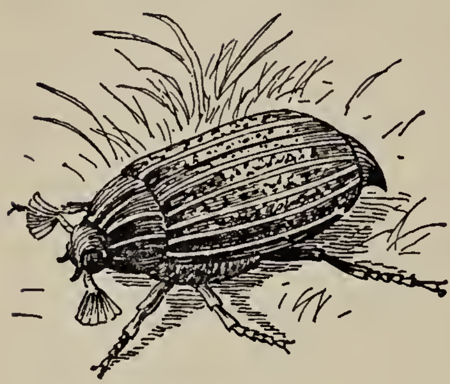
Lesson XLIII

More about Insects

"Shall we see what else we can find to say about insects, Fred?" asked Willie. "Norah would be pleased, I am sure."

"Very well," said Fred, "suppose we talk about the insect's body. The most important part of the body is the chest. To it are joined the wings above and the legs on the under side.

"Most insects have two pairs of wings; some have not a second pair, but have instead a pair of balancers; some have no wings at all. Beetles have two pairs of wings, but the outer ones are simply hard, horny cases, meant to protect the thin, gauzy, true wings beneath.



"Insects have always three pairs of legs, which are formed on one general plan—a thigh, a leg, and a foot. Yet teacher says few things are more wonderful than the way in which the legs and feet of each insect are formed to suit the kind of life it has to live.

"Some insects, like the grasshopper, have long legs and stout strong thighs for jumping and leaping. Some are meant to burrow in the ground, like the mole and the rabbit. They are provided with short strong fore-legs, and feet made on purpose for digging."

"How wonderful it all is," said Norah.

"The bee's legs," continued Fred, "are made hollow at the sides to form a sort of basket, in which it carries home the pollen from the flowers for feeding purposes."

"Fred, I think I can remember about the way the insect breathes," said Willie.

"Go on then, Will," said Fred.

"Teacher says insects have neither lungs nor gills," said Will. "They have instead two long canals in the body, which end in breathing holes, in the loose side skin, joining the upper and lower segments. These canals send out branching tubes into all parts of the body.

"The air which is taken in at the breathing holes on the sides of the body is carried into every corner by these tubes, and so the blood all over the body is cleansed. The insect's blood is cold and colorless."

Lesson XLIV

More about Carbonic Acid Gas

"Every lesson we have," said Willie, "seems to show us, more and more, what a wonderful world we live in. How lucky we are to be learning all these things. Whoever would have thought, now, that poisonous carbonic acid gas could be of any use? Why, it would kill us and every living animal if we were to breathe it for only two or three minutes. You remember our chats about the coal mine, Norah, and the terrible explosions of fire-damp that sometimes happen?"

"Oh yes. I shall never forget those dreadful places," said Norah.

"Well, teacher told us that after the explosion takes place," said Willie, "dense masses of carbonic acid gas are formed. The miners call the gas after-damp or choke-damp. Dreadful as the first danger is, more are killed afterwards—suffocated by the choke-damp—than by the explosion."

"But do you mean to say that this poisonous gas can be of any use?" asked Norah.

"Let me tell you," said Fred. "You know that the breathing of animals and the burning of fires are constantly sending out some of this gas into the air. There is always carbonic gas in the air."

"Of course there must be," said Norah. "It seems to me that with fires and animals always making it, there must be a very large quantity of this gas in the air."

"Ah!" said Fred, "that is just the most wonderful part of it. Teacher showed us a saucer which he had filled with clear lime-water during the morning. By the time we saw it there was the same milky, cloudy-looking film on its surface, as we saw in the lime-water when we breathed into it the other day.

"That proved of course that carbonic acid gas had been acting on the lime-water. But the water below was quite clear, and there was only a film on the surface. That tells us clearly that after all there is only a very small quantity of carbonic acid gas in the air.

"Now, as we know that such a large amount of this gas is being constantly sent into the air, we must begin to wonder what becomes of it.

"Teacher told us all about it. Plants of every kind take in from the air carbonic acid gas, and use it to build up their own substance. It is their food.

"This is why there is never very much carbonic acid gas in the air. As quickly as it is formed by breathing and burning, it is taken in by plants as their food."

Lesson XLV

Life History of an Insect

"Look at that beautiful butterfly, Norah," said Fred. "Its life has been a strange one. If you will shut your eyes, and listen again as you did to the frog, you shall hear its history.

"'I was once an ugly caterpillar.' This is what it would say if it could speak. 'I remember the time when I first crawled out from an egg I was a very small, ugly, crawling thing then

My mother had laid the eggs for me and my brothers and sisters in the leaf of a cabbage. She put them there because she knew that we youngsters would be very fond of cabbage.

That's about the only kind thing she ever did for us, for she died soon after.

"'Some mothers, I am told, put their eggs in other places. The fly, for instance, likes to lay her eggs in the meat in the butchers' shops, so that the maggots that come from them may have plenty of the food they like best. The beetle places her eggs in a dung-heap, where the grubs that come from them are sure to get plenty to eat.

" 'Well, it seems to me, whether we were caterpillars, maggots, or grubs, we did justice to the food our good mothers provided for us. I know I did little else but feed from morning till night, and as I fed and grew, my skin split in all directions, and I threw it off from time to time, always finding a new one underneath. I don't think the gardener can have been very fond of us, for we must have done a good deal of damage to his plants.

" 'Well, after a while I suppose I must have reached my full size, for I had no longer any desire to eat. I seemed to want to sleep. I rolled myself up in a snug ball, gummed myself into the leaf, and covered myself with a loosely-spun, flossy silk. I think people called me a pupa or a chrysalis in those days; but how long it lasted I never shall know.

" 'All I do know is that when at length I woke up, I was no longer a crawling larva, nor was I a pupa; but I found myself furnished with the most beautiful wings. I could fly. I was never more to crawl like an ugly worm. I can't tell you the joy I felt.

"'Well, I soon began to feel my appetite; but I had now quite a loathing for those nasty cabbage-leaves and green food. Something—I can't tell what it was—seemed to urge me to go to the flowers. I went; and then I found I had a beautiful trunk for sucking up the sweet juice of the flowers. This has been my food ever since.

"'I have been so happy, but I begin to feel it will soon end. I must go and lay my eggs in that cabbage, and then I fear it will be all over with me.'"

Lesson XLVI

Parts of a Plant

"Do you remember the difference between a mineral and a plant, Norah?" asked Willie.

"Let me see," said Norah; "I think I can tell. A plant consists of several distinct parts, such as the root, stem, leaves, flowers, and so on; but any part of a mineral is exactly the same as another. Then, too, a plant lives and grows in the ground, but a mineral is not living matter, and it does not grow."

"That's very good," said Willie. "These different parts have different work to do for the plant. They are none of them alike, and none of them do the same kind of work as the others do. They are called organs. Teacher says an organ is some special part of the plant which has some special work to do.

"Ah, here comes Fred," he added. "We'll all go out into the garden, and examine some of the plants for ourselves."

Away they went, and found father busy as usual. As soon as he knew what they wanted, however, he found them the plants best suited to their purpose, and said they might go on with their chat without any fear of worrying him.

"Look," said Fred, as he knocked a plant out of the pot, and shook the soil away from it. "Here is a plant that has a root, a stem, and some leaves, but no other parts of any sort. It had the same three organs as soon as it first peeped above the soil, and as long as it lives it will have them.

"Let us examine this young scarlet bean. It is only just unfolding its leaves above the ground, but it has all three parts. It could not live without each one of them.

"Teacher says we may call them the vital organs of the plant, because they have to do with the everyday life of the plant. The name vital comes from a word which means life. These organs—the root, stem, and leaves—do the work of feeding the plant and making it grow. They may therefore be called also the organs of growth."

"Run round now and see my early peas," said father. "You will find some other parts there, I think."

As they went along the path Fred picked a rose and put it in his buttonhole.

"Do you think," he said, as he did so, "the rose-bush will die because I have picked this flower, Norah?"

"Oh no," said Norah; "it does not hurt a plant to pick its flowers. We pick bunches of flowers all through the summer."

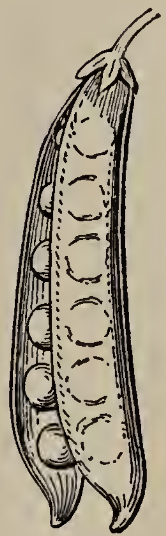
"What does that prove then?"

"It proves," replied Norah, "that the flowers are not vital organs. They have nothing to do with the work of keeping the plant alive."

"Quite right," said Fred. "Now let us examine these peas. Here are some in flower. What a pity it is that they wither and die!

Just look at this one. The pretty flower-leaves seem quite dried up.

"But don't let us be in a hurry," he continued. "Look again. In place of the pretty flower there is a little green pod. See, here is a larger one, and here is one larger still. Let us pick it and see what there is inside."



Norah opened the pod, and saw that it contained a number of little round peas. Fred explained that these are the seeds of the plant.

"The work of the flowers," he added, "is to form these pods with the seeds in them. The seeds, if we left them to ripen, would grow next season into new plants.

"Teacher says that the flowers, although they are not vital organs, have a very important work to do. They have to produce the seeds, which will grow into new plants. We call them organs of reproduction."

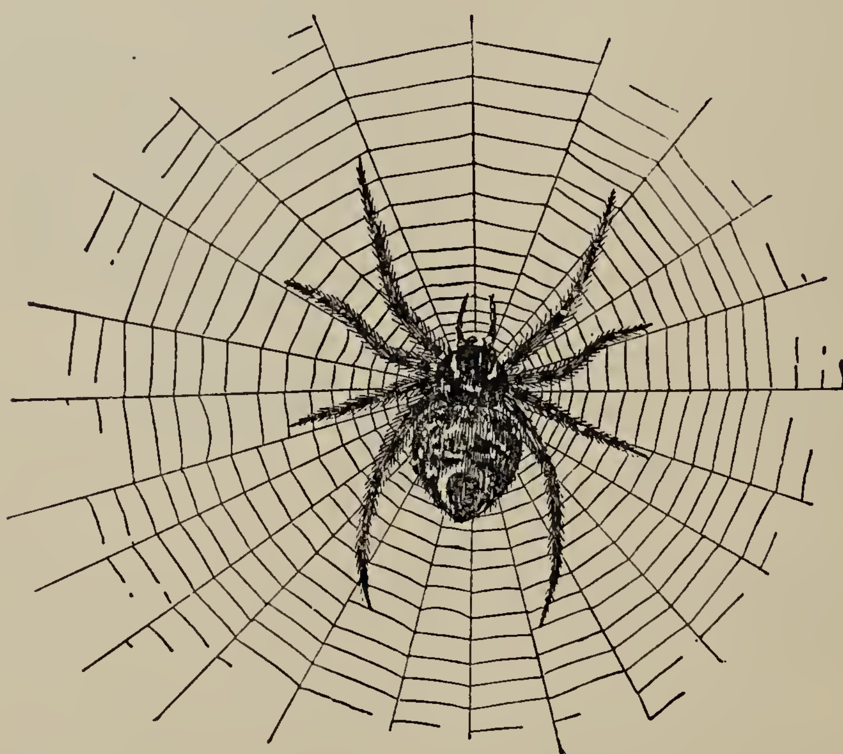
Lesson XLVII

The Spider

"I've found one, Fred," said Willie, running in almost breathless from the garden; "such a monster. He has made a web in the bower by the apple-tree. Bring Norah, and we'll see what we can find to talk about."

A few minutes later they were all seated in the bower, watching a great garden-spider.

"Now, Norah," said Fred, "I daresay you think, as I did till to-day, that the spider is an



insect. But, thanks to teacher, I shall be able to show you that he is not an insect. He is quite distinct from the insects in nearly every way. I wonder what you could tell me about the spider and his habits, from all you have seen of him."

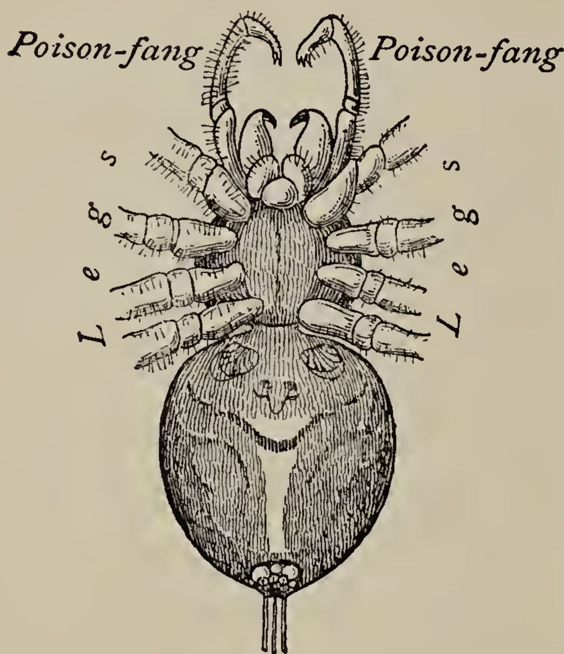
"I have often watched the spider, lying in wait to entrap the flies and other insects in his terrible net," said Norah. "I should call him a sly, crafty creature. From the fierce, savage way he attacks them, too, he must be cruel and bloodthirsty."

"You have watched him well, Norah. He is a fierce, hungry hunter," said Fred. "He preys upon insects, and is as much a terror to them as certain beasts, birds, reptiles, and fishes are to other animals. Unlike them, however, he weaves a trap or snare in which to capture his prey.

"Now let us look and see what he himself is like. His body is in two parts—not three, like the body of an insect. The upper part consists of the head and chest together; the lower part is the belly. The whole of the body, too, is covered with a close-fitting, soft, smooth coat—not with overlapping segments, like those of the insects.

"The eyes, again, are quite different from the insects' eyes. Some spiders have two eyes; some have as many as six or eight pairs of eyes. But the eye is always single, and not made up of a cluster of small eyes like the eyes of the insects. They are so set in the head as to enable him to see on all sides at once. They are protected with a hard, transparent, horny covering, and so there is no need of eyelids.

"On the front of the head are the feelers, which end in a pair of terrible claws. These are his weapons of attack. Teacher says each feeler is in two parts, which can be folded together. The claw, besides being a sharp, tearing weapon, is really a hollow tube, through which the spider darts a poisonous fluid into the wounds of his victim."



"The horrid little monster," said Norah. "He is even more savage than I thought he was."

"The head is simply the front part of the chest," continued Fred. "The hinder part bears the legs but no wings. Spiders never have wings.

"The legs are always eight in number—four pairs. Insects, you know, have six legs. The legs are of great length, and each one consists of seven jointed parts. The spider, having no wings, has to rely on these long nimble legs in pursuing his prey."

Lesson XLVIII

The Vital Organs of the Plant

"Suppose we have another chat about plants to-night, Norah," said Fred. "Let us try again to think of some of our early lessons. We will begin with the root. Shall we?

"The root, you know, is that part of the plant which makes its way down into the soil. It has to hold the plant firmly in the ground, and supply it with earth-food from the soil.

"Some plants have fibrous roots. The fibres spring from the stem, and spread downwards through the soil. Grass and grain have fibrous roots, and so have all plants that die down every year. Such plants are called Annuals. We sow the seeds for them in the spring.

"Other plants have thick, fleshy tap-roots. These live for two seasons, and are called

Biennials. The tap-root is a sort of storehouse of food for the plant, to feed it when it wakes up after its winter sleep.

"Trees and shrubs live for many years, and are called Perennials. They have fibrous roots, but these fibres are really thick and woody."

"You must remember, Norah," said Willie, "that, whatever the class of root may be, the actual feeders are the delicate root-hairs. These root-hairs are absorbent, and absorb the dissolved earth-food from the soil."

"Take the stem next," said Fred. "This is the part of the plant which grows upwards into the air, and bears the leaves and flowers. But I want you to think only of the leaves now. Can you tell me the different parts of a leaf, Norah ?"

"Let me see," said Norah ; "it has a footstalk and a blade ; the ribs and veins spread through the blade.

"Oh, and I remember, too, that the surface of the leaf is closely set with breathing pores," she added.

"You must remember," said Fred, "that the footstalk, ribs, and veins all form channels for the upward flow of the earth-food. And now I want you to think of something else. What becomes of the carbonic acid gas which is always being formed in the air ?"

"Oh, I know," said Norah. "The plants take it in. Then I suppose it is the carbonic acid gas that is absorbed by the breathing pores of the leaves."

"Yes, it is," said Fred. "The breathing pores absorb carbonic acid gas from the air. In the leaves this gas is broken up. The plant takes for its own use a part of it, which we call carbon or charcoal, and breathes out the rest to the air again. The carbon is absorbed by the sap, which now becomes air-food as well as earth-food, and is carried away into all parts of the plant."

Lesson XLIX

The Spider's Web

"Fred, I noticed that when we looked at the spider, we said nothing about the lower half of his body," said Norah.

"No," said Fred; "I left that for another time. Suppose we talk about it now. This part of the spider's body is very wonderful. It contains the machinery (if I may call it so) for spinning the web. The material for the thread is a gummy fluid, which is prepared inside the body.

"On the under part of the body near the end are the openings of four tiny tubes—the spinnerets. Teacher says that the end of each of these tubes is pierced like a pepper-box with about 1000 little holes. It is through these tiny holes that the spider sends out the gummy fluid which is to make his thread. It hardens as soon as it reaches the air.

"Now I am going to tell you the most wonderful thing of all. The spider's hind feet are made like a pair of combs. These combs gather up and twist into a rope the fine threads from all the four spinnerets—1000 from each, or 4000 in all.

"Think for yourself, Norah, what a fine delicate thing the thread of the spider's web is. Fancy that fine thread being itself made up of no less than 4000 separate threads twisted together by the spider's feet. Isn't it wonderful?

"Next time you see a spider at work weaving his web, watch him. He is very clever.

"He first spins a very long thread, and then leaves it hanging from his body, for the wind to catch it, and carry it across the space, and lodge it on some twig or wall, to which it will cling.

"Then he proceeds to stretch other threads across in a similar way, making them all meet in the centre.

"Lastly, he runs a fine thread round and round, starting from the centre and ending at length on the outside.

"Our garden-spider makes the most beautiful of all webs, and he can finish it in about an hour. Then he retires to his den close by, to watch for the flies that come buzzing about.

"Presently he sees an unwary fly entangled in the elastic thread and struggling to get free. Then with a sudden rush he throws himself on his victim, holds it fast in his cruel claws, which, as I told you, are both spears and poison-fangs, and at the same time binds its body with more cords.

"Thus close-bound in every limb, bruised, bitten, and poisoned, the poor fly is dragged away to the den of the victor in triumph."

"There is just one other difference between

spiders and insects," said Willie, "which we ought not to forget. You know that insects have to pass through three distinct stages from the egg to the perfect form—the larva, the pupa, and the perfect insect.

"The little spider begins the world from the egg at once in its perfect form, and as it grows bigger and bigger it casts its skin from time to time."

Lesson L

Parts of a Flower

"Our lesson to-day," said Fred, "was about the flowers. You know, Norah, we called the flowers the organs of reproduction. Their work is to produce new plants, which shall live after the parent plant is dead.

"Teacher had some wallflowers to show us in class, and as we have plenty in the garden, we may as well pick a few to talk about now.

"If we examine one of these flowers, we shall see that there is an outer covering, which holds it to the flower-stalk. This is called the calyx. I will remove it from the flower, and, you see, it is really a little cup into which the rest of the flower fits.

"It is made up of four little pointed green leaves, which we call sepals. Teacher says that flowers have not all the same number of sepals. Some have more than this, some have less.

"When the flower was only a little bud, these sepals folded themselves round it to protect it from wind, rain, and sun till it was fit to burst open."

"The sepals of most flowers are green," said Willie, "but some, like the fuchsia, have richly-colored sepals."

"Now let us look at the second or inner cup of flower-leaves, which rests in the calyx," said Fred. "We call it the corolla. It consists of four separate leaves, larger than those of the calyx. Instead of being coarse and green, these, you see, are soft and velvety to the touch, and richly colored.

"They are called petals. These beautiful flower-leaves, although so bright and gay, are not the most important parts of the flower. Those parts are hidden away in the very centre. Teacher says that the petals, like the sepals, act as a covering to protect the inner parts of the flower while they are first forming in the bud."

"Teacher told us too," said Willie, "that the flower-leaves of the corolla, like those of the calyx, are not always four in number; and that they are not always separate, as they are in the wallflower.

"Look at this convolvulus, Norah. Its petals are joined together at their edges to form a sort of bell."

Lesson LI

More about the Flowers

"Suppose we come and finish our talk about the flowers," said Fred.

"We had to leave the inner parts of the flower yesterday, you know. Let us pick a few more fresh flowers, and I'll see what I can remember to tell you about them.

"We will commence by carefully plucking off the petals. Now we can see, growing up from the bottom of the flower-cup, some long slender stalks, with a little oval knob at the top of each. The little stalks are called stamens; the knobs at the top of them are the anthers."

"Oh yes, Fred," said Norah. "I remember. They are not really knobs. They are little hollow boxes or cases, and they are full of a fine yellow dust which we call pollen."

"Quite right, Norah," said Fred. "Look while I shake the anthers over this piece of white paper, and you will see some of the pollen-dust on the paper.

"There is nothing more I can tell you about stamens and anthers, so we will strip them off the flower and see what we can find next. Here, in the very centre, surrounded by all the other parts, we find the most important part of the flower. We call it the pistil. It consists of two parts, the stigma and the ovary."

"I think even the stigma is a very wonderful part of the flower," said Willie. "Teacher says that if we could see it through a glass that would magnify it, we should find it to be very loose and spongy, with a broad top, which is mostly covered with a sticky fluid.

"This stigma has to catch the pollen as it falls. The pollen must make its way down the stigma into the ovary below. The broad head, the sticky top, and the loose spongy substance of the stigma seem fitted in a wonderful way for this work."

"Suppose we have a look at the ovary now," said Fred. "I have got, on purpose, some flowers that look dry and withered. You will see if we pull this one to pieces that the ovary has been growing very large.

"This lower part of the pistil is swollen out larger than the upper part. It forms a sort of case or box. It is called the ovary, because it contains a number of little round bodies, the ovules, placed in order side by side. These ovules in time become seeds. When we speak of the fruit of a plant we always mean this seed-vessel or ovary."

Lesson LII

The Flower and its Work

"We have learned a good deal about the parts of the flower," said Fred. "Suppose we now follow the flower in its work from the time it is a little growing flower-bud till it withers and drops to the ground. Let us begin with it as a bud, before it bursts open. What part of the flower has any work to do at this time?"

"The calyx, with its strong outer covering of sepals, protects the little bud against the weather," said Willie.

"And I should think," said Norah, "that the soft, velvety petals of the corolla fold round the young stamens and pistil, and make a smooth delicate covering to save them from injury."

"Quite right, both of you," said Fred. "That's just what teacher told us. When the stamens, anthers, and pistil are able to stand the weather, all the flower-leaves open, and those inner parts grow quickly. The ovary has its tiny ovules from the first, but the ovules cannot become actual seeds without the pollen from the anthers. The anthers are the first to ripen, and as they ripen they burst open and scatter their yellow pollen. Some of it falls on the stigma of the pistil, and at once forces its way through its spongy substance till it reaches the ovules in the ovary.

"Now listen while I tell you a very wonderful thing about this pollen. You have seen some of the yellow dust. Think how fine the grains of this pollen must be. What a wonderful thing it is then that each little grain of pollen carries down to the ovules a small drop of fluid. It is this very fluid which changes the ovules into actual seeds."

"Let me tell Norah about the bees," said Willie; "for after all I think that is more wonderful still.

"You know, Norah, that the bees use the pollen of the flowers to feed their young. They collect it by flying from flower to flower, and carry it home in those hollow baskets in the sides of their thighs. You know, too, that they get honey from the flowers. The honey is always found at the very bottom of the flower. The bees cannot get at it without forcing aside the stamens, and most likely bursting some of the anthers. But they get both the things they want, and besides this they get dusted all over with the pollen.

"Now comes the wonderful part. Some flowers have a pistil but no stamens. Such flowers could never produce seeds, for they have no pollen to send into the ovary. Imagine then the bees going about their own work, without a thought for the flowers, and yet doing the very thing that is wanted for them. They visit a flower and become covered with its pollen; they go to the next, and, while forcing their way in, leave some of that pollen behind, and the whole work is done."

Lesson LIII

Seeds

"Last time we were talking about the flowers, Norah, I showed you the ovules in the little seed-pod of the wallflower," said Fred. "I have here one of the same seed-pods, so ripe that it is splitting open. You can see that the ovules have become actual seeds.

"We had a lesson about seeds yesterday, and I'll try now and tell you what teacher said about them. He had some scarlet beans and broad beans for us to examine in class, so I've got a few now to show you. I have been soaking some of them in water, just as teacher did. Let us begin with them. The first thing to notice is the loose wrinkled skin that covers the seed. If we peel it off we see that it is thick and tough. The skin of these dry seeds is smooth and shiny. It is wrinkled because it has been soaked. We call this tough outer skin the testa.

Of course you can see that it is meant to protect the inner kernel. I want you next to notice this long black scar along the edge of the seed. It marks the spot where the seed was attached to the ovary or seed-vessel. It is called the hilum.

"Now please watch me. I don't think I can do this as well as teacher did it, but I'll try."

Fred then slit the testa of one of the soaked seeds very carefully with a knife, and peeled it off, so as to show the inner parts.

"Now look, Norah," he said; "the seed really consists of two pieces placed side by side. Both pieces are thick and solid. They are called the seed-leaves.

"See, they are not separate," he went on; "they are joined together in one spot, the hilum, as by a sort of hinge. I wonder whether I can spread the two seed-leaves open without breaking the hinge. That's good. Now have a look at this little hinge. It is the most important part of the seed, for it is the germ of the new plant.

"Look at this part of it which points upwards. It is called the plumule. It is really a tiny bud, which will make its way up through the soil, and form the stem and leaves. The other part pointing downwards makes its way into the soil and becomes the root. It is called the radicle. Radicle means a little root."

Lesson LIV

Seedlings

"Can you tell me, Fred, all about the way the little seed germ grows till it becomes a plant, able to take care of itself?" asked Norah. "I learned so many new things from what you told me about the seeds, that I should so much like to know just how that little germ grows."

"Well, I think I can tell you something about it," said Fred, "for that was our lesson this morning.

"You know that every seed contains in itself the germ of a little plant, with root, stem, leaves, only waiting for an opportunity to grow. Teacher showed us some peas which he was growing

in flower-pots; some were only just starting, others were quite little plants with leaves.

"After the seeds have been in the damp soil for some time the first effect of the moisture is to cause the testa to swell up and wrinkle till at last it bursts. While this has been going on, the warmth and moisture together have made the tiny germ wake up, as it were, from its long sleep and begin to stretch itself out.

"It happens, you see, that the testa splits just at the time when the germ has woke up, is beginning to grow, and wants more room.

"The two parts of the germ grow—the radicle forcing its way down into the soil, the plumule upwards towards the surface, for light and air."

"But I can't see how these little germs can grow," said Norah. "Where do they get their food? It must be some time before the little root can grow enough to make its way into the soil, and then I think you told me that the root-hairs, which feed the plant, don't come for some time. I can't see how the little thing is to get any earth-food; and it certainly can't get any air-food, for there are no leaves—no parts of it above the ground."

"Well," said Fred, "I am not surprised to see you puzzled about this, Norah. But you may be sure everything is well arranged, although it is very wonderful. Those seed-leaves are simply a storehouse of food for the little germ, with just the proper kind of food, and just the proper quantity, to feed it till it can grow root-hairs to absorb earth-food from the soil, and leaves to breathe in air-food from the air.

"As soon as this is the case the seed-leaves wither and drop off."

Lesson LV

The Seed-Leaves

"Would you like to learn a little more about those wonderful seed-leaves, Norah?" asked Fred. "There are a few things about them which we ought not to forget."

"Oh yes, do tell me, Fred," said Norah. "The more I know about all these wonderful things, the more I want to know."

"Well then," said Fred, "the seeds which I brought you to examine had all of them two seed-leaves, and the germ itself formed the little hinge to hold the two parts together.

"Let us take the scarlet bean seed once more. Open it and you will see that it has double seed-leaves. But I want you now to look not at the seed, but at the green leaves of the plant. Here are some of them.

"Hold one up to the light and tell me what you notice about it."

"Oh, I know," said Norah. "You mean the veins. These are net-veined leaves. The veins branch out and spread through the leaf in all directions."

"Quite right, Norah," said Fred; "and now I want you to examine some other seeds for yourself. Here are some large seeds such as apple-seeds and pear-seeds, plum and cherry stones, almonds, acorns, and peas. Here, too, I have some small ones—radish seeds and mustard seeds. If you open them you will find that every one of them has double seed-leaves.

"Now take them one by one and think what kind of leaves they produce when they grow up into plants. The apple tree and the pear tree, the plum and cherry trees, the almond tree and the oak all have the same net-veined leaves. So have peas, radishes, and the mustard plant.

"In fact, you may say that all plants bear net-veined leaves that come from seeds with double seed-leaves."

"But what about the plants with parallel-veined leaves,—leaves whose veins run side by side?" asked Norah. "Haven't these got double seed-leaves too, Fred?"

"No," said Fred, "they have only one seed-leaf. I can't tell you anything about those now. Teacher has promised to give us a lesson on them to-morrow."

Lesson LVI

The Single Seed-Leaf

"Fred, you promised to tell me about those plants whose seeds have a single seed-leaf," said Norah. "Did you get your lesson to-day?"

"Yes," said Fred, "we had our lesson, and I'll try and tell you all I can about it, if you would like to hear it.

"To make us understand these seeds properly, teacher brought some grains of Indian corn for us to examine. Some of the grains he had kept in soak for a few days, so that instead of being hard and brittle, they were soft enough for him to cut easily. He gave me some of the soaked grains after the lesson. Here they

are. I'll try and show you what teacher showed us in class. Don't laugh if I can't do it so well as he did, Will. Here, lend me your knife. It's sharper than mine.

"Well," he continued, "teacher took one of the grains and cut away with his knife, like this, all the outside mass of soft substance, and presently—bravo! I've done it."

"Done what, Fred?" asked Norah.

"Why, look; all this outside stuff has nothing to do with the actual seed. Here is the seed. It was embedded in the middle of the grain.

"Now suppose we have a look at the seed itself. See, Norah, it has a plumule and a radicle, just like other seeds. But I want you to notice the outer part of the seed. This, you see, is all in one piece, and folds itself completely round the plumule and radicle as if to protect them. You remember, of course, that the germs of the other seeds are protected by double seed-leaves. This has only a single seed-leaf.

"Now think of our old lessons on the grain plants, and you will be able to tell me what kind of leaves they all have, corn as well as the rest."

"These all have parallel-veined leaves," said Norah. "The veins run through the leaves, side by side, from base to tip."

"Remember, then," said Fred, "that all plants bear parallel-veined leaves that come from seeds with a single seed-leaf."

"Does the little seedling get its food from this one seed-leaf, Fred?"

"No, Norah," said Fred. "In all these seeds the food store is laid up in the grain, which surrounds the germ, and not in the seed-leaf. The seed-leaf itself is not thick and solid like those of the bean."

Lesson LVII

The Bark

"We have had a lesson to-day, Norah, about the tree's coat," said Willie.

"The tree's coat," said Norah. "What do you mean?"

"Come into the garden," said Will, "and

we'll show you. Look at this old tree. How rough and gnarled its stem and branches.

look. This outside part of the tree is quite different from the rest of the woody stem. We call it the bark. This is what I meant by the tree's coat."

"Will is quite right," said Fred, "only I should perhaps call it, as teacher did, a double coat, for there is an inner one beneath this rough one on the outside.

"But let us look at some of the other plants in the garden," Fred continued. "I can easily peel off from any of them an outer skin or covering. It is not so thick, of course, as the tree's coat, but it is the same sort of thing. It covers the plants just as the skin covers our bodies. It is in each case the bark of the plant.

"The outer bark which we can see is, of course, thicker and coarser than the one beneath it. We might call this the tree's greatcoat. The cork which we use for so many purposes is the outer bark of a kind of oak tree which grows in Spain. These trees are grown only for their bark, which is stripped off them from time to time.

"The bark of the oak, larch, chestnut, willow, and birch, when ground small and steeped in water, gives a liquid called ooze, which is used in tanning leather.

"The outer bark of certain trees is used for dyeing; and the valuable medicine, quinine, is made from the bark of the cinchona tree.

"The inner bark is an entirely different substance. Teacher showed us some strips of the inner bark of the bass-wood tree, and father has lent me this to show you now."

"Why, Fred," said Norah, "this is the common bass, that father uses for tying up his plants in the garden."

"Yes, Norah, and this common bass or bast is really the inner bark of the bass-wood, as I said just now.

"Now I want to give you one thing to think about," he added. "Long, long ago, before people had paper, they used to write on thin sheets of this bass to make their books. The Latin name for book is *liber*. This is why bass is sometimes called liber."

Lesson LVIII

Kinds of Bass

"When we were talking about bass the other day," said Fred, "there was not time to say all I wanted to say about it. Let us start again now.

"Take a piece of the bass, Norah, and try to break it by pulling it. You cannot do so. You find it very tough and strong. It is for this reason, and also because it is very pliant, and can be easily bent or twisted, that bass is so useful.

"The bass of the bass-wood is used for making ropes, mats, shoes, hats, and other things. You know, too, how useful the bass matting is in the garden for tying-up purposes and for covering plants in the winter time.

"Teacher says much of the bast of commerce comes from Russia.

"Although, properly speaking, the name bass is confined to the inner bark of the bass-wood, we commonly apply the name to the inner bark of many other plants.

"Do you know what my white collar is made of, Norah?"

"It is made of linen," she replied.

"Quite right," said Fred, "but what is linen?"

"Linen comes from the flax plant."

"Yes, but what part of the plant gives us this linen? I don't think you can tell. It comes from the stem. It is made from the bass or bast fibres of the inner bark.

"The Latin name for flax," he continued, "is *linum*. Here are some of the flax seeds. We call them linseed. The cloth we make from the bast fibres we call linen."

"Rope, twine, and cordage of every kind, canvas, sail-cloth, and sacking are all made from the bast fibres in the inner bark of another plant, something like the flax," said Willie. "This is the hemp plant. It is grown in many parts of the world, and is not unlike the common nettle in appearance. You know you give hemp seed to the thrush and blackbird, Norah."

"Teacher showed us some other bast fibre called jute," said Fred. "This, like the flax and hemp, comes from the stem of the plant. It is the inner bark of the stem. Jute is not so tough and strong as flax or hemp, but it has a smooth, glossy appearance. It is largely used because it is cheap and easily worked. It is often mixed with flax and hemp to make certain kinds of goods."

Lesson LIX

Flax

"The bast fibres of the flax plant are so important," said Fred, "that teacher gave us a special lesson on the plant and its cultivation. The flax plant grows from two to three feet high, and bears pretty blue flowers at the top of its long slender stalks. When the flower dies off it leaves behind a pod, or seed-vessel, full of little, flat, oval seeds.

"It is a curious fact that in warm countries the plants produce excellent seeds; but the bast fibres of the stem are not so good as in plants grown in temperate climates.

"In warm countries therefore the flax plant is grown chiefly for its seeds. When pressed, these seeds yield linseed oil; and the oil-cake which is left behind is used for feeding cattle.

"In cooler climates the plant is grown mainly for the bast fibres of its inner bark, which is used for making linen. In the north of Ireland, and in Belgium, Holland, and Russia, we may see fields of flax plants growing like corn and other crops. The plant is an annual, and very easily grown. It is sown in the spring, and is ready for gathering in July.

"When the plants are fit to gather, their leaves fall off, their stems begin to turn yellow, and the seed-pods to become brown. Men, women, and children are then sent into the fields to uproot the plants by hand. They are all pulled up separately, carefully dried in the sun, and then laid in order, crossing each other, with the root ends pointing one way.

"A great deal needs to be done to the flax before it is fit for the manufacturer. First of all, the seed-pods have to be removed from the stalks. This is done by a process called rippling. Men called ripplers sit in front of a coarse, iron comb fixed with its teeth uppermost. This is the ripple. The men draw the stalks one by one through the teeth, and so separate the seed-pods from them.

"The next process is known as rotting or retting. The object of it is to separate the bast fibres from the woody part of the stem. To do this the stalks are steeped, root downwards, in a shallow pool for about ten or twelve days.

"At the end of that time the fibres become loose, and may be easily removed from the rest of the stem, which has rotted into a soft pulpy sort of matter. The hard, woody parts, which have not rotted, have been made very brittle by the steeping. These are separated from the fibres by a process called breaking and scutching.

"The flax, freed from all this useless matter, is tied up in bundles weighing from 16 to 24 lbs. each, and is ready for the workman."

Lesson LX

Linen-Making

"We have been learning to-day," said Willie, "how linen is made from the flax fibres. Teacher showed us some pieces of fine linen, duck, diaper, huckaback, and damask, and, side by side with them, some of the scutched fibres we were talking about the other day. He said that those beautiful linen goods are called fabrics, because they are made by a skilled workman. We could easily imagine for ourselves how much clever skill is needed in the workman to change the rough fibres into those useful materials for our use.

"Fred, will you tell all about it?" he added. "You will do it better than I can."

"Well, let us see where to begin," said Fred, "and I will try.

"Suppose we begin with the scutched fibres, as they are first taken to the mill. The fibres are of different quality in different parts of the stem.

Near the root they are coarse and strong; in the middle they are finer; and near the top they are very fine but not very strong. The first business then is to cut the fibres into three lengths, to keep each of them for special fabrics.

"They have next to undergo a process called heckling. This is nothing more than drawing the fibres again and again through a comb, to straighten them and make them lie side by side. The comb is called a heckle, and is placed with its steel teeth upright.

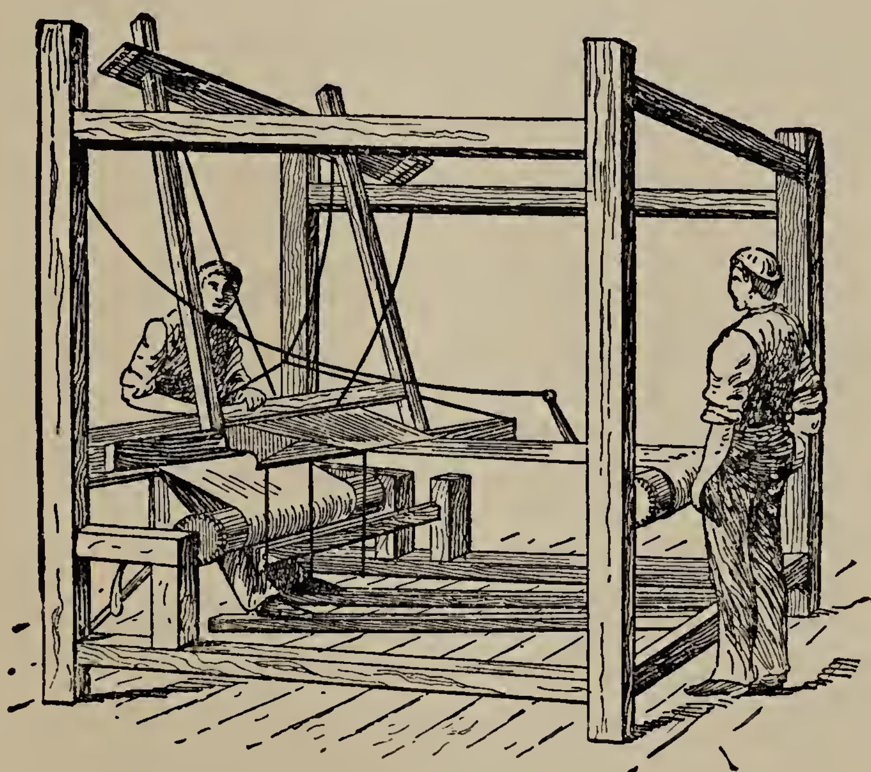
"As the heckler draws the fibres through this heckle he combs out a great deal of coarse broken fibre. This would not do for such fabrics as teacher showed us, but is used up in making coarser goods.

"The heckled fibres are called line. They are fine and soft to the touch, but very tough and will not easily break. They have a glistening, silvery appearance, not unlike silk, and are of a pale yellow color.

"Tough as these line fibres are, they would not be strong enough singly. Look at this piece of linen. I will pull one of the threads out. This thread, you see, consists of a number of fine threads twisted together. The fibres of the heckled line have first to be twisted into strong thread like this before they can be made into any fabric.

"The process of twisting the fibres into thread is called spinning; the spun thread is called flax yarn.

"The rest of the work is done by the weaver in a machine called a loom. In the loom a great many threads are arranged closely, side by side,



in front of the workman. These are called the warp. The alternate threads of the warp can be raised and lowered as the weaver pleases. A shuttle, which the man passes from hand to hand, through the warp, carries another thread, called the woof. The fabric is woven by passing the shuttle to and fro, and at the same time raising first one set of the warp threads and then another."

SUMMARY OF LESSONS

Lesson I.—Water—Its Properties

Water is a liquid. Liquids have no shape of their own; they take the shape of the vessel which holds them; they flow about; they break up into drops; they will not stand in a heap, but always keep a level surface.

Water is a transparent, colorless, tasteless, inodorous liquid.

Lesson II.—Some of the Uses of Water

Water is the natural drink of man and all animals. It is the natural cleanser. We cook and prepare our food with water. Water absorbs gases. Fishes can breathe in water, because it contains air. Drinking water should be kept from bad smells of all kinds.

Lesson III.—Birds and their Covering

Birds are clothed with feathers. They do not nurse their young. They have wings, and fly in the air. Birds have large quill feathers in the wings and tail, and clothing feathers to cover the body. Some birds have soft down under-jackets.

Lesson IV.—A Feather

A feather consists of a stem and a web. The stem has a hollow quill, and a shaft filled with light pith. The web consists of barbs; the edges of the barbs are held together by the barbules. All the bird's feathers point backwards.

Lesson V.—The Uses of Feathers

The quill feathers of some birds are used for ladies' hats and bonnets, for ornaments, and for making pens; the clothing feathers and down for stuffing beds, pillows, cushions, etc.

Lesson VI.—Water as a Solvent

Water loosens or breaks up salt and other substances into tiny particles too small to be seen. It dissolves them. The dissolved particles are absorbed into the pores of the water. We can get rid of them only by boiling the water. Water will not dissolve some substances. They are insoluble.

Lesson VII.—Further Uses of Water

Water feeds the growing plants by dissolving proper food for them out of the soil. Water dissolves many substances out of the earth as it soaks through. It forms mineral springs and brine springs ; but all this water falls in rain from the clouds at first.

Lesson VIII.—Birds

The bones of the bird are thin, light, and hollow. Instead of arms and hands the bird has wings for flying. Birds have beaks, which serve as mouth and teeth all in one. Their feet are claws ; but they are not all alike.

Lesson IX.—Water in other Forms

Steam is water in another form. The heat breaks up the water into tiny particles lighter than the air. They rise and float away in the air. The air absorbs them into its pores. Vapor is something like steam. Some amount of vapor rises even in cold weather. Dry air can evaporate and absorb more moisture than damp air.

Lesson X.—Vapor in the Air

Most of the vapor in the air is evaporated from the great bodies of water in the hot regions of the world. But some vapor is always rising into the air everywhere. Plants and animals send out vapor into the air.

Lesson XI.—Birds and their Beaks

Birds of prey have hooked, pointed beaks, for tearing flesh ; fishing-birds have long, sharp beaks, for stabbing the fish in the water ; the boring-birds have strong, pointed beaks, for boring into the bark of the trees to find insects.

Lesson XII.—More about Beaks

Ducks, geese, and swans have flat, shovel-like bills. They grope in the mud with them for grubs and worms. The nut-cracking birds have hard, strong, hooked bills. The beaks of the seed-eating birds are short and cone-shaped.

Lesson XIII.—Vapor—What becomes of It

Cold condenses the vapor in the air into drops of moisture. Steam is at first invisible. It becomes visible when the cold air begins to condense it. All vapor is at first invisible.

Lesson XIV.—Clouds, Rain, Dew

Invisible vapor is always rising from the earth. It becomes visible when it is condensed. If the air around us is cold the vapor condenses into a fog. It usually rises and floats away before it condenses, and then forms a cloud. When the cloud condenses into actual water, it drops as rain. Vapor condenses on the cold earth and forms dew.

Lesson XV.—Birds—Their Legs and Feet

The birds of prey have strongly-jointed toes, with sharp, hooked talons. They use them for seizing their prey. The perching-birds have long, slender toes, for grasping the twigs. They rest securely on the branch by the mere bending of the knee.

Lesson XVI.—Birds—More about Legs and Feet

Climbing-birds have two toes in front and two behind. They live entirely in the trees. The scratchers have strong, blunt claws for scratching in the ground to find their food. The waders have long, stilt-like legs, for walking in the water. Their long necks and bills are to enable them to reach their prey in the water. The feet of all swimming-birds are webbed. The runners have long legs, and short, thick, solid toes.

Lesson XVII.—Solid Water

Ice is solid water. Heat will change this solid, like others, into liquid. Very little heat is wanted. Ice melts in the warm hand. The liquid water would become solid again in a cold place.

Lesson XVIII.—Ice, Hail, and Snow

Ice is lighter than water. It floats on the top of the water. If it were not for this, fishes and plants would all die. Hail consists of frozen rain-drops. Snow is frozen vapor.

Lesson XIX.—A Snake

Snakes have no limbs. They move on their ribs. They have many pairs of ribs. The skeleton is jointed with ball-and socket joints. The body is covered with scales.

Lesson XX.—How the Snake Feeds

The snake's teeth are small and sharp-pointed; they all bend backwards; they hold the victim as it is being swallowed. The snake swallows its prey whole, because every part of its body is made for this kind of feeding.

Lesson XXI.—Mercury

Mercury is a liquid metal. It flows about, and readily breaks up into tiny drops. It is silvery-white, and has a bright metallic lustre. It is nearly fourteen times as heavy as water.

Lesson XXII.—The Poisonous Snakes

The poisonous snakes have two long fangs in the upper jaw, and poison-bags at the roots of them. Their bite either kills their victim or makes it insensible. The forked tongue is harmless.

Lesson XXIII.—The Non-Poisonous Snakes

The non-poisonous snakes have no poison fangs; many spring at their victim, wind their long bodies round it, and crush it to death. Some of them are huge serpents, fifty and sixty feet long.

Lesson XXIV.—Mercury—Its Preparation and Uses

The ore from which mercury is obtained is a rough, brown stone, called cinnabar. It contains, besides the metal, a large quantity of sulphur. It is broken up into small pieces and heated, and the sulphur passes away in vapor, leaving the liquid metal behind.

Lesson XXV.—The Frog

The frog can live in the water as well as on the land. His hind feet are webbed for swimming. His body is always cold. He has teeth in the upper jaw only. The root of his tongue is in front; he can throw it forward a long way, to catch the insects and grubs, which are his food.

Lesson XXVI.—Air

Air is an actual substance, although we cannot see it. There is air everywhere. Air occupies space, and is compressible.

Lesson XXVII.—More about the Frog

The frog has no ribs; he does not breathe as we do. He shuts his mouth, sucks the air up through his nostrils, and swallows it in gulps. The frog can breathe through his moist skin. He spends all the winter in the mud at the bottom of the pond. His blood is always cold.

Lesson XXVIII.—More about the Air

A square box, a foot across each way, holds one ounce of air. Air presses with equal force downwards, upwards, sideways, and in all directions.

Lesson XXIX.—The Frog and the Toad compared

The toad is larger, more clumsily built, and more awkward in its movements than the frog.

The frog is a swimmer. Its hind feet are webbed.	The toad has no web between its toes.
The frog has a smooth skin.	The toad has a rough, warty skin.
The frog has teeth in the upper jaw.	The toad has no teeth.
The frog leaps on his long hind legs.	The toad moves slowly, with short jumps.
The frog spends much of its time in the water.	The toad goes to the water only in the spring to lay its eggs.

Lesson XXX.—Gases

Gases are fluids—they flow. Liquids always keep a level surface, but gases have no surface. They spread themselves out in all directions.

Lesson XXXI.—The Frog—Its Life History

The frog comes from an egg laid by its parent at the bottom of the water. The egg rises to the surface, and is hatched by the heat of the sun. It begins life as a tadpole, with no limbs ; it breathes by means of gills, like a fish, and feeds upon the green shoots of the water-plants. It passes through various stages, and undergoes many changes for about six or eight weeks. At the end of that time it leaves the water as a fully-developed frog, with lungs, not gills ; with four limbs, but no tail ; and with even its feeding instincts changed. The frog feeds upon worms, grubs, and insects.

Lesson XXXII.—Coal-Gas

Coal-gas is invisible. It has a powerful, unpleasant smell, and it burns with a bright flame. It is very explosive if mixed with air. This is the fire-damp of the coal-mine. The Davy lamp is safe, because, although the explosive gas can enter through the gauze, and burn round the flame, the flame itself cannot pass out through the gauze.

Lesson XXXIII.—A Fish

The fish breathes by means of gills. The gills are placed just behind the jaws. They look red, because of the blood which is flowing through them. The fish takes in water at its mouth, and passes it over the gills. The water contains air in its pores. The gills suck this air out of the water.

Lesson XXXIV.—More about Coal-Gas

To make coal-gas, the coal is heated in closed retorts, and the gas and smoke are allowed to pass away by long pipes, into great receivers, to be purified. The cinders left from the burning are coke.

Lesson XXXV.—More about the Fish

Fishes have cold blood, because they can take in only small quantities of air by means of their gills. They do not want a warm coat. Their clothing is formed of scales. Each scale is fixed into the skin in front only. The scales overlap one another, press close to the body, and help the fish in its movements.

Lesson XXXVI.—Balloons

Balloons float in the air, because they are filled with coal-gas, which is only about half as heavy as the air. The dense, heavy air forces the balloon up, just as water forces a cork to its surface.

Lesson XXXVII.—How the Fish Moves

The shape of its body, pointed both ways, helps the fish in its movements. The separate bones of the backbone have little hollow cups, or sockets, on both sides. The edges of the cups fit together ; this makes the body very flexible. The fish uses its tail as its propeller, to move it through the water. The other fins are to balance its body.

Lesson XXXVIII.—Tar

Smoke, as well as gas, is given off from the burning coal at the gas-works. It is all made to pass through water. The gas is very light, and rises to the surface to be carried away in pipes. The smoke is heavy, and sinks to the bottom as tar. Tar is a thick, black, heavy liquid, something like molasses. It has a powerful smell and a bitter taste. It is insoluble in water. It is very inflammable. Coal-naphtha and pitch are got from tar.

Lesson XXXIX.—The Fish and its Food

The fish has small, sharp teeth, pointing backward, but no cutting, or grinding teeth. They devour other fish, and swallow their prey whole. Fishes lay eggs in immense numbers. The roe of the fish contains the eggs. The young fry that come from these eggs form the food of other fishes.

Lesson XL.—Paraffin Oil

Paraffin, petroleum, or rock-oil is an inflammable liquid, which is obtained from oil-springs in the ground. The coarse liquid, as it is pumped up, is purified, and made to yield paraffin wax, and refined oil for burning in lamps. Benzine is another inflammable liquid—even more inflammable than paraffin oil. It is made by refining coal-tar naphtha. An ordinary warm day will cause it to evaporate. It is the vapor, or gas rising from it, which takes fire and explodes, when it mixes with the air.

Lesson XLI.—An Insect

The word in-sect means "cut into." The body is in three parts—head, chest, and belly, and is made up of ringed segments. Insects have no brain. The eyes are at the sides of the head; each eye is a cluster of small eyes. Some insects have jaws for biting their food. The jaws always open sideways. Some have trunks for sucking up the food on which they live.

Lesson XLII.—Carbonic Acid Gas

Carbonic acid is an invisible gas, without either taste or smell. It is very heavy, and can be poured out like water. It extinguishes a flame. Nothing can burn in it. It turns clear lime-water white, like milk. Carbonic acid is formed when burning of any sort goes on. Animals send out carbonic acid when they breathe.

Lesson XLIII.—More about Insects

Most insects have two pairs of wings—some have no wings. All have three pairs of legs. The legs and feet are made to suit the life of each kind of insect. Some are made for leaping, some for digging in the ground. The bee's thighs form baskets. Insects have neither lungs nor gills. They breathe through slits in the loose, side skin.

Lesson XLIV.—More about Carbonic Acid Gas

The breathing of animals and burning of all sorts are constantly loading the air with carbonic acid gas. Plants breathe in this carbonic acid through the breathing pores of their leaves. It is part of their food.

Lesson XLV.—Life History of an Insect

Insects come from eggs, laid by the parent, in the midst of some substance which will serve for food. The larva, or grub, comes from the egg, and feeds voraciously till it reaches its full size. It then changes to the "pupa" form, from which it emerges as a perfect insect.

Lesson XLVI.—Parts of a Plant

A plant has distinct organs, each of which perform some special kind of work. Some of these—the root, stem, and leaves—are known as vital organs. They have to feed the plant and make it grow. The flowers are organs of reproduction. They form the seeds, from which new plants will spring.

Lesson XLVII.—The Spider

The spider is not an insect. Its body is in two parts, and is not covered with overlapping segments. It has eight legs, and no wings. The eyes are single, and not in clusters. They are very prominent. On the front of the head are a pair of terrible claws. The spider is a fierce, cruel, and sly hunter.

Lesson XLVIII.—The Vital Organs of the Plant

All annuals have fibrous roots. Biennials live for two years, and only flower in the second ; they have fleshy tap-roots, which are meant to serve as a store of food, for the plant to live upon. Trees and shrubs live for many years, and are called perennials. They have fibrous, woody roots. The leaf consists of a foot-stalk and a blade. Ribs and veins spread through the blade, and its surface is set with breathing-pores. The stem, the foot-stalk, the ribs, and the veins carry up the sap. The breathing-pores suck in carbonic acid gas from the air. The sap takes carbon from this gas to feed the plant.

Lesson XLIX.—The Spider's Web

The spider spins its web with a gummy fluid from its own body. Each thread is made up of 4000 separate strands. The web is wonderfully made. The young spider begins its life in its perfect form ; it does not pass through different stages, as the insects do.

Lesson L.—Parts of a Flower

The outside flower-leaves, or sepals, form the calyx. The inner circle of flower-leaves are called petals ; they form the corolla. Both of these help to protect the delicate, inner parts of the flower.

Lesson LI.—More about the Flowers

Inside the circle of petals are the stamens. The anthers at the top of the stamens are full of pollen. The pistil is the innermost part of the flower. The lower part of it is the ovary, and contains the ovules, which grow into seeds. It is the pollen from the anthers which changes the ovules into seeds.

Lesson LII.—The Flower and its Work

The sepals and petals protect the stamens and pistil while they are young. The pollen grains from the anthers pass down into the ovary, and carry a small drop of fluid to make the ovules into seeds. The bees, and other insects, do most of the work of carrying pollen from one flower to another.

Lesson LIII.—Seeds

The seed of a bean consists of two parts, or seed-leaves, joined together at the hilum by a little hinge. This hinge is the germ of the new plant. Part of it, the plumule, will grow upwards through the soil ; the other part, the radicle, will make its way downwards, and form the root.

Lesson LIV.—Seedlings

When the seed is put into the ground, the outside skin swells and bursts, the germ wakes up, and commences to grow—the plumule making its way upwards, the radicle pushing itself down into the soil. The seed-leaves feed it as it is growing, till the root can take up food from the soil.

Lesson LV.—The Seed-Leaves

The bean seed has two seed-leaves. The plant which comes from it has net-veined leaves. All plants with net-veined leaves come from seeds which have double seed-leaves.

Lesson LVI.—The Single Seed-Leaf

The germ of the grains has only one seed-leaf. The food-store to feed the growing germ is laid up in the grain itself, and not in the seed-leaf. All plants that grow from such seeds have parallel-veined leaves.

Lesson LVII.—The Bark

The bark is the outside coat of the plant. The bark of trees is thick. Cork is the bark of a tree. The bark of the oak and other trees is used in tanning. The bark of some trees is used for dyeing ; that of others for medicine.

Lesson LVIII.—Kinds of Bass

The inner bark of the bass-wood yields bass or *liber.* The inner bark of the flax-plant yields material for making linen. Canvas, rope, and cordage are made from the inner bark of the hemp-plant. Jute is the inner bark of a plant, and is used for many purposes.

Lesson LIX.—Flax

The flax-plant grows from two to three feet high, and bears pretty blue flowers. Its seeds are the linseed from which we extract oil. Linen is made from the bass fibres of the inner bark of the stem. The plants are pulled up when ripe, and after drying in the sun are rippled to remove the seed-pods. They are then steeped in water to make the soft parts of the stem rot. The scutching process, which follows, is to remove the hard, woody parts, and leave the bast fibres free.

Lesson LX.—Linen-Making

The manufacture begins by cutting the bundles of scutched fibres into three lengths, after which they are heckled, or combed. The heckling draws the fibres out, and straightens them. They are then called line. The line is spun into yarn, and the yarn is woven into fabrics in the loom.

THE END

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