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The Story of The Oak Tree

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Ezra Bowen"*

The Story of the Oak Tree

By Mrs. Ezra Bowen

EASTON, PA.

THE CHEMICAL PUBLISHING COMPANY

1924

LONDON, ENGLAND:
WILLIAMS & NORGATE,
14 HENRIETTA STREET, COVENT GARDEN, W. C.

TOKYO, JAPAN:
MARUZEN COMPANY, LTD.
11-16 NIHONBASHI TORI-SANCHOME

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MAR 17 '24

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PREFACE

This little book was written in response to the demand for a school reader about Nature which would tell, not merely sentimental anecdotes about the bunny, the violet and the rose, but a continuous story of the life history of some living thing. The author chose the Oak Tree as her subject simply because its story serves as a complete illustration of that underlying fact of Nature, the interdependence of all things—the inseparable linkage of animate and inanimate, of atom, molecule, and substance, of soil, plant, animal, and man.

To Professor Edward Hart, Dean of the Scientific Department, Lafayette College, and to Dr. James Waddell Tupper, Professor of English Literature at Lafayette College, the author wishes to make grateful acknowledgment for their helpful criticism in the preparation of this book.

MRS. EZRA BOWEN

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CHAPTER I

Tree Feelings

White Oak in Winter

I wonder if they like it—being trees?

I suppose they do.

It must feel so good to have the ground so flat,
And feel yourself stand straight up like that.
So stiff in the middle, and then branch at ease,
Big boughs that arch, small ones that bend and blow,
And all those fringy leaves that flutter so.
You'd think they'd break off at the lower end

When the wind fills them, and their great heads bend.
But when you think of all the roots they drop,
As much at bottom as there is on top,
A double tree, widespread in earth and air,
Like a reflection in the water there.

Caroline Perkins Sutson.

If you stood alone under an oak tree on a summer's day, and that oak tree could talk, it might have a great deal to say to you. Perhaps it would say:

"Look here, you boy or girl, maybe you think because I can't run around the way you do, that I'm not just as much alive and as much use in the world as you are. Well—maybe not quite as much alive nor quite as useful, because nothing in all Nature is as much alive or as important as man, but I want you to know I'm more than a stick of wood to be cut up for chairs and tables! I'm a *plant*, a living plant, like my half-brother the pine and my sweet cousin the rose, and even my homely great-niece the cabbage. You're an animal, and I'm a plant, and in the order of the living world plants come next beneath animals. And not so very far beneath, either. Animals live on plants; if every plant in the ground should shrivel up and die, all you men and animals would die of starvation very soon after. I'm not much of a food plant myself, like a bean or a potato, but doesn't

the farmer's pig root up and eat my acorns, and then who eats the pig? Why, you do, and very sweet he tastes, too, when roasted in the oven all brown and sugary.

Men have always been friendly to me. When I was an acorn my mother, who was five hundred years old, used to tell me things she had heard her father say—I guess he heard them from his father in turn—about how long centuries ago men used to worship me as a god. They thought anything so big and strong, anything that lived so many hundred years, must have some kind of a god inside it. Your own forefathers in England, the Druids, fierce men and heathen, hunters and fighters, had groves of sacred oaks. Whatever grew upon an oak they looked upon as a gift from heaven, especially mistletoe. When they found mistletoe growing around my great grandfather's trunk, they would fetch a priest in a white robe and he would take his golden knife and cut off the mistletoe. My grandfather would have been flattered and pleased by this attention if he had not been so disgusted by the cruel custom of sacrificing two white bulls right under his branches every time the mistletoe was cut.

And even earlier than this, down on the shores of the warm Mediterranean Sea the ancient Greeks had a temple at Dodona. The temple was dedicated to Zeus, and near the temple was an old, old oak tree which the Greeks said

contained an oracle—a god who could foretell events. The priests who tended this oak slept on the ground beneath its branches; when the time came to ask the oracle a question, these priests would raise their heads and catch the answer in the rustling of the myriad leaves above. When the breeze was not blowing and the leaves made no sound the priests found their answers in the moaning of the doves upon the spreading branches.

Wise men of Greece in later years, philosophers whose names are still revered, believed that we trees could see, and hear, and feel, and think. Maybe you have helped to plant a tree on Arbor Day, or maybe you have watched them plant a tree after the ceremony of laying the cornerstone of a new church, or school, or public library. Have you ever wondered why they did this? I will tell you why. It is the last remnant of the beliefs of your ancestors, who thought the life of a man and the life of a tree were bound up together. When a child was born those ancient people would fix upon some young tree as that child's tree. If the tree grew tall and strong, the child grew tall and strong; if the tree sickened and died, it was ten to one the boy would die too. In Africa to-day there live savages who abandon their homes and fly from their village forever if the sacred tree of the village dies. In ancient Rome there stood in the market place a fig tree sacred to Romulus, founder of that great city.

One summer when the fig tree withered and died the whole population was thrown into the greatest excitement.

There is a story three thousand years old; it comes from Egypt, and it is called the Tale of the Two Brothers. One of the brothers left his heart on the top of a tree. As long as the tree stood that brother lived happily, but when his enemy felled the tree that brother died.

Right here in your own land, in Hartford, Connecticut, there stood an oak tree—my great-uncle, by the way—called the Charter Oak of Hartford. It was believed to be several hundred years old. When the pioneer settlers were felling trees to clear the land, the Indians begged them to spare the oak. “It has been the guide of our ancestors for centuries,” they said, “as to the time of planting our corn. When the leaves are the size of a mouse’s ears, then is the time to put the seed into the ground.” The white men respected the Indians’ wish, and the oak outlived many generations of settlers. In the summer of 1856 it fell in a fierce wind storm, and the sorrowful people tolled the sunset bells that evening and brought their musicians to play a funeral dirge over the mighty fallen trunk.

Well, my grandfather never had much fun out of being worshiped, and I don’t think I’d like it much myself.

Acorns from Scarlet Oak

You don't make any friends by being worshiped. No, I don't want to be worshiped, I want to be understood. I want you humans to be real friends with me, and that means you will have to study me a little, in order to get acquainted. Study my roots and trunk and leaves;

find out how I live and eat; whether I ever go to sleep; how I keep warm and how I feed my children, the acorns.

Do you know why I haven't legs to run around in search of food the way animals do? Because I don't need to! I can dig my roots into the moist soil and stay comfortably just where I am, because I eat water and sunlight. Yes, I do! Water from the soil and sunlight from above

Leaves of White Oak

the earth. I have a pretty good time doing it, too. I'd like to go on and tell you myself just how my leaves turn that sunlight into food, because it's as wonderful as magic, but my uncle the chestnut oak told me once that other people always know more about you than you do yourself, so I'm going to let the lady in this book do the telling.

And when she is all through, if you read what she writes, I think you and I will be much better friends than ever we were before!"

CHAPTER II

The Acorn, the Root and the Seedling Oak

Every boy and girl knows what an acorn looks like. Haven't you ever found an acorn with a bulging, curly end made of tiny woody scales, and pulled the end off and hollowed out the nut to make a cup and saucer? Acorns from the red oak make the best cups and saucers, and acorns from the scarlet oak make the best tops for spinning. They are small tops, of course, but they whirl as merrily as any of your big, showy, painted ones.

Cup and Saucer made from Acorns
of Red Oak

Every tree bears its fruit; just as the apple is the fruit of the apple tree, so is the acorn the fruit of the oak. And in the fruit lies the seed.

Warm and dry and protected, when in Autumn the ripe fruit falls from the branch the seed sleeps there in its acorn coat, waiting to be planted, waiting for Spring and the feel of the moist earth pressing its sides to waken it once more to life and growth.

We humans think we are great travellers, and so we are, some of us. But plants travel too, they journey

over land and sea; they leave their homes and settle in strange countries. When we set out we carry a great bother of luggage with us, but plants travel as light as the wind. They travel as seeds. When the mother plant bears light seeds such as the dandelion or the fir tree, the wind snatches up handfuls of it and scatters it far and wide. Every plant yields many, many more seeds than will ever grow. If one seed in ten thousand grows, Nature is satisfied. Inside the poppy are cuddled thirty-two thousand seeds. If all these seeds became flowers there would be poppies, poppies everywhere—enough to put us all to sleep! Sometimes seeds have wings, like the thistle and the milkweed. Have you never pulled a handful of ripe milkweed from the pod and blown it into the air to watch the seeds sail upward and away on their white silken wings? Where the mother plant leans out over a stream the seeds will fall perhaps in the water and be whirled away; if the river is broad and deep the swift current will carry the seed even out to the ocean, and it will be washed up to grow on foreign shores.

Of course, a seed has to be strong and hardy to endure a bath in salt water, to endure being battered by the wind and scorched dry by the sun, or to lie unprotected on frozen, wintry ground waiting to be planted. Some seeds can be left for dozens of years and will grow when covered with earth. The little seed is the hardiest part

of the tree. The tall mother tree needs a constant supply of food, it needs a certain evenness of climate and it must have sunlight, but it knows how to build for its seed such a close woven coat that the seed can go to sleep for years and forget all about food and shelter.

The acorn is not as hardy as some other seeds. It must have a certain amount of moisture; if it dries up, it dies. Naturally, a big clumsy seed like an acorn cannot travel on the wind. Many seeds too heavy to be blown by the breeze are carried by birds; a bird will alight and walk about on muddy ground, and when it rises into the air soil sticks to its feet. In the soil seeds may be hidden; when the earth dries on the bird's feet, the seeds fall to the ground. There are seeds, like the apple seed, with coats so tough the birds cannot digest them; when a robin, pecking at an apple, swallows an apple seed the seed passes through the bird's body and drops to earth.

But birds do not carry acorns. When a ripe acorn falls, its first wish, if it has any wishes, is to get away from under the branches of the parent tree. It cannot grow there, because those leafy branches will shade away the sunlight it loves, and those big roots will reach out and absorb the food in the earth for yards around, so that there will not be enough left for the hungry little acorn. So the acorn lies there and lies there, helpless. Once or twice the wind turns it over, and once a boy

picks it up as he passes by and looks as if he would like to bite into it to try if it be sweet or bitter. Lucky for him that he throws it away, because this acorn comes from a scarlet oak, and only the white oak bears sweet fruit!

At last the acorn is away from under the mother tree. There it lies in the sunshine. If only someone would come and plant it in the ground! It has no power of gathering its own food, either water or sunlight; it needs no food now while it is asleep, but within its shell is stored food all carefully prepared by the mother tree. And because this food is so carefully prepared, it is good food for animals.

The squirrel knows this, and along he comes frisking, tail up; he seizes that acorn between his sharp teeth and scurries off with it. But because he is a thrifty animal he does not eat the nut; winter will soon be here and food will be scarce, so he buries it carefully not far from his home, meaning to come back one day when he is especially hungry and dig it up.

But he never comes back because he forgets all about it, or else he cannot find the spot where he has buried it so carefully.

So the winter long the acorn sleeps snugly underground.

And then comes Spring!

And with Spring the germ within the acorn, the magic, mysterious, *living* germ begins to grow. The acorn

Sprouting Acorns

bursts into life! You have seen onions sprout, have you not, when the cook left them too long in the warm kitchen cupboard? Well, the acorn sprout curves *down* into the earth, feeling for the moisture which feeds it. Very soon after this first shoot has taken hold, another shoot grows up to the air, feeling in its turn for light and for the plant food con-

tained in the air. The downward growth is the root, and the other is the *crown* growth, because stem, branches and leaves together are called the crown of the tree. For a time the growth of both root and stem is sustained by food that has been stored in the acorn by the mother tree, but soon the tiny root hairs along the outside of the roots become strong enough to absorb their own moisture.

What is it, do you suppose, that makes the root grow down and the stem grow up? People have been so curious to find out the reason for this that they have made experiments to try to fool the root. They have twisted the acorn round so the stem would grow down and the root up, but every time the wise root and stem have righted themselves and grown the way they knew was best for them. The only attraction that can bring the root upward is water. Roots are such thirsty things that when the soil is very dry and water is above, they will follow the moisture.

Down there in the moist darkness that it loves the tiny root begins to grow. It feels its way straight down into the earth, for this first shoot is the central root of the tree, the tap root, and the tap root always grows straight down. The end of this root is so sensitive that men have called it the brain of the tree. It grows against something rough, is slightly wounded, and turns away from the thing that has scratched it. There is a great scientist named Mr. Arthur Thomson who understands the trees so well that he can tell you better than I can just how the root moves.

"It moves gently," he says, "against grains of soil, and the touch causes it to move gently to and fro; it feels its way through the cracks of the soil. It comes to a dry region and bends to the moister side."

Growing things, you see, are very sensitive. If a growing stem be sharply struck it curves as though in pain, and stays curved for some time. When a root feels the pressure of a stone, it grows more slowly until it has grown around the stone. Climbing plants, however, like to feel something hard pressing against them; not until it feels the porch pillar against it does the Virginia Creeper begin to cling and climb in earnest. If you had something fastened to the top of your head which pulled you gently upward all the time, I doubt whether, when you are twenty, you would be much taller than Nature has already planned—but it helps growing plants to be pulled along. Trailing stems in a stream grow longer when the current is swift than when it is slow.

Roots have two important things to do; one is to absorb water, and the other is to hold up the tree. We have told how little, delicate hairs grow out along the root; it is these hairs which absorb the moisture. Every Autumn when the leaves die these hairs die also, because in winter the ground is frozen hard and the roots can gather no water. The tree in winter lives upon food stored up in summer, but the next Spring new little hairs begin to grow upon the roots and reach out for more water to feed the thirsty tree trunk.

You know now what sensitive, exploring things roots are, but do you know how strong they are, and how

deep they grow? They are the long, muscular fingers of the tree, thrust down into the earth to hold the heavy trunk and branches when the fierce winds blow. A great oak tree stands on the hillside near my home. In winter when the north winds sweep the hill front I have seen that oak bend until I thought it must break and crash to its death, but those strong and loyal fingers gripping the earth beneath held it in safety. Some roots have been known to grow as deep as twenty feet into the ground. There is as much tree underground as there is above; woodsmen and foresters say you can measure the roots by the branches; that is, they say the roots extend below ground as far as the branches are spread above. This is not strictly true, but it is truth to say there is as much tree below ground as above, only below ground the roots are bunched together in a thick mass.

Roots, as well as trunk and branches, put on a coat of bark. Did you ever try to pull up a tree, just a little, slender sapling? If you did, I believe you had a pretty hard pull before you decided you would just let that tree stand after all. Some roots are so tough and strong that our forefathers made fences of them after they had pulled up the stumps to clear the land for tillage. In New England you can see to this day fences built more than a hundred years ago of stout white pine roots.

It is a brave fight the acorn puts up before the sapling grows big enough to take care of itself. Read what Robert Douglas says about this fight:

“The acorn is the only seed I can think of which is left by Nature to take care of itself. It matures without protection, falls heavily and helplessly to the ground to be eaten or trodden on by animals, yet the few which escape and those which are trodden under are well able to compete in the race for life. While the elm and maple seeds are drying up on the surface, the hickories and walnuts waiting to be cracked, the acorn is at work with its coat off. It drives its tap root into the earth in spite of grass and brush and litter. No matter if it is shaded by forest trees so that the sun cannot penetrate; it will manage to make a short stem and a few leaves the first season, enough to keep life in the root which will drill deeper and deeper. When age or accident removes the tree which has overshadowed it, then it will assert itself. Fires may run over the land destroying almost everything else; the oak will be killed to the ground but it will throw up a new shoot the next spring, the root will keep enlarging and when the opportunity comes will make a vigorous growth and throw out strong side roots and often care no more for its tap root which has been its only support than the frog cares for the tail of the tadpole after it has got on its own legs.”

A brave fight, little acorn! We want you to win it,—
what shall we do to help you?

“Plant me in the Spring,” you cry, “when the squirrels
and mice have plenty of other food and won’t scratch for
me and dig me up! Plant me in the Spring, and give
me plenty of room; don’t crowd me in between other
trees or other acorns. Give me plenty of sunlight, and
for three or four years, while I am still a frail seedling
oak, care for me a little.

Then I’ll show what I can do!”

CHAPTER III

The Stem and the Branches

Full in the midst of his own strength he stands
Stretching his brawny arms and leafy hands
His shade protects the plains, his head the hill
 commands.

Virgil.

No wonder the Latin poet wrote this way about the oak. There is a majesty about an oak tree that reminds one of a king of olden time, a king of the Vikings, strong and unconquered, lifting his crowned head proudly to the storm. And indeed there live oak trees which have seen the birth and death of many a king; oaks stand to-day in England which were saplings when William the Conqueror landed with his Norman warriors. Always the oak has been the symbol of strength and loyalty.

I saw a moving picture once, about Robin Hood and his band of merry outlaws who lived in Sherwood Forest, in England, so long ago. Robin Hood was a true knight, it was all a mistake that he was outlawed; he and his men spent their days in righting the wrongs of the oppressed; they robbed the rich to feed the poor. One day Sherwood Forest was surrounded by the soldiers of the cruel Sheriff of Nottingham. Robin Hood gave his order,

“To the trees, my men!”

Stealthily the sheriff's soldiers closed in about the glades of the forest where they knew Robin Hood and his men made their home.

"Aha," they said, "we have caught our bird this time unaware!"

Suddenly they heard the whizz of arrows; arrows seemed to rain from the sky. They cried surrender and looked up. There were Robin Hood's men, swarming in the trees above. Along the broad branches of the great oaks they leaped and ran, bows in hand, their coats and caps of Lincoln green splashed with the sunlight which filtered down between the leaves.

Small wonder that the soldiers cried, "Enough!"

Look at an oak in winter if you would see its true grandeur, in winter when it is stripped of leaves. Yonder towers its great trunk, one hundred feet high; its massive gnarled limbs show strength to their very twig tips.

It seems hardly fitting, does it, to speak of this great trunk as a *stem*? Daisies have stems, and violets have stems, but daisies and violets are only little modest flowering plants. And that is what the oak tree is—a flowering plant. There is nothing little and modest about it, to be sure, but it is a plant just the same, and is made up, like all the higher plants, of a root, a stem with branches, and leaves. The stem does two things; it holds the branches aloft, spreading the leaves to the sun-

light, and it serves as a channel through which water containing plant food rises and flows from root to leaf

and down again to nourish each living part. The branches are part of the trunk and do the same work.

If you look at the drawing you will see how a tree trunk is built, and you will understand how the tree grows.

On the outside, as you know, is the rough bark. This is the tree's coat, to keep it warm, and the tree's armor to keep it from being bruised or punctured. Right next inside the bark grows a thin layer of delicate wood called the *cambium*. When a boy takes a block of wood to carve out a whistle, he will find that the easiest way to strip off the bark is to run his jack knife down this cambium layer. The cambium is the vital part of the trunk, the only part which never sleeps nor withers from the birth of the tree to its death. All up and down this thin cambium layer is stored the winter long food for the young buds and roots of next Spring, because, as you will remember, the buds and roots must be fed until they grow strong enough to gather nourishment for themselves. A storehouse of food means to us shelves of apples and potatoes and nuts and sugar, so that if we cut down a tree in winter we might think that next Spring's buds and roots would have a very thin diet, because the starch and the sugar in the cambium storehouse, like all other stored plant food, is invisible to us.

Each year, commencing in the Spring, onto the outer surface of the cambium layer—that is, the part next to the bark—grows a new strip of bark. This new strip, together with other growth within the trunk, pushes out and strains the old bark until it cracks and dies. Then it falls off the tree and the new bark takes its place. Trees, just like boys and girls, do their most rapid growing between March and July. Did you know that? Boys and girls grow tall in Spring, and in the Fall they put on weight,—like the plant they store up food for future use, because fat is stored food. In early summer, at the time of the tree's most rapid growth, you can pull a strip of bark from an oak without hurting the tree. Pull off the bark, and underneath you will see the cambium. Then, if the cambium be carefully shaded from the scorching sun, or if the weather remain moist and cloudy for a few days, the cambium will grow a coat of bark right over the bared and tender surface—provided the surface has not been bruised or broken. A young tree can be stripped of its bark for several feet and heal its own wound, but to strip a tree is not a kind thing to do.

At the same time that the cambium is growing its yearly outside strip, it is also adding an inside layer. These yearly layers can be plainly seen on the sawed-off trunk of an oak. They go round and round, and if you count them you will know just how old the tree is, because each

of the rings means a year's growth. Now, this inside layer which the cambium grows is the sapwood, the part of the trunk where the sap, or plant food, flows up and down to the leaves and roots. At first this new layer is tender and spongy so that the sap can move freely; at this early time it is called Spring Wood. As the summer advances the Spring Wood becomes harder and firmer; then it is called Summer Wood. After a long, long time, perhaps when the tree is thirty or even seventy-five years old, the pores—invisible holes and ducts through which the sap flowed—fill up with gums or other solid matter. Then, when the sap can no longer flow through it the sapwood is called Heartwood; new sapwood has grown all around and outside it, and this old remaining heartwood is the pith of the tree.

We do not entirely understand the use of this tree pith, we do not know exactly what part it plays in the busy life of the tree. The pith can dry and rot away until the inside of the tree is entirely hollow, like a hollow pillar, yet the tree lives and grows. When a tree is diseased men can cut out great chunks of the rotting wood and fill up the cavity with cement, just as the dentist can fill your tooth with cement and not injure the living tissue which surrounds the filling.

If you will look once more at the picture of the sawed log you will see some lines going out from the center like

the spokes of a wheel. These streaks of wood are harder than the pith, and they are called pith rays, because they glance out from the pith as rays stream out from the sun. When foresters saw a log this way, the saw, as it runs through the center of the tree, will cut the same way the pith rays run; that is parallel with the pith rays. The pith rays run in wavy lines, so boards cut from the center along these rays will show wavy lines or streaks. In oak timber these shiny streaks are called "silver sheen;" the wood cut in this way is known as quartered oak and is the choicest timber of the tree. Perhaps your mother has a dining room table or a library table made of quartered oak; look at its smooth polished surface and trace the beautiful pattern of the "silver sheen."

And now that you understand how the stem is built—bark, cambium, sapwood and pith—it is time to speak of something marvelous, something the tree does which has puzzled wise men for a long time, and puzzles them still. There are men, great scientists, who spend their lives studying plants, plants of all kinds, high and low, from the lichen that grows on the rock to the noblest oak that ever spread its leafy branches to the sun. The study of plants is called botany, so these men are known as botanists; and little by little, as the centuries go by these botanists have coaxed from Mother Nature her secrets. They have had to be patient, because Nature guards her

secrets jealously; they have had to work through discouragement that would have made you or me give up long ago, and there are still many secrets which Nature has not yet yielded to their understanding. And this is one of them:

What makes the sap run up the tree?

We said a while ago that the tree stem has two duties to perform; it holds the branches aloft, spreading the leaves to the sun, and it serves as a channel through which water containing plant food—in other words, the sap—rises and flows from root to leaf and down again to nourish each living part. But what makes the sap rise? There is no giant lying hidden in the earth, ready to put his mouth to the stem base and puff out his great cheeks and *blow* the sap up the tall trunk to the highest twig! And there is no wood fairy on the highest leaf to put her lips to the twig and with a magic breath *suck* the sap up from the roots! Boys and girls, what makes the sap circulate in your own healthy bodies? Blood, you know, is our sap; it flows from our toes to our finger tips to nourish the living cells of our bodies. And what makes it flow? The heart, you say! And right you are; the heart is the strong and tireless engine which pumps the blood through our limbs. But who can find the heart of a tree, or who can discover any strong pump to send the sap spurting up the trunk?

Naturally enough, the botanists have made guesses about this mystery, and good enough guesses too, but they are not satisfied with their own guesses. They have guessed that something called root pressure makes the sap ascend, something called osmotic pressure, and another something they name capillary attraction draws the sap up along the trunk. But do not let anybody frighten you by big words. If you study the trees and come to know them and to love them, I should not be surprised if one of you, when you are grown, and have learned much, much more about the trees than I can tell you, should lean your ear some day to the root of an oak and hear the great secret!

Wood-Grain

This is the way that the sap river ran
From the root to the top of the tree
 Silent and dark
 Under the bark
Working a wonderful plan
 That the leaves never know,
 And the branches that grow
On the brink of the tide never see.

John B. Tabb.

CHAPTER IV

The Leaf

Nobody has to be told how beautiful the Spring is. We all know that without being told. We should know it if we were blind; we could lift our nostrils to the softness of the air and the freshness of new things growing in the earth. All the living world—men and animals

Leaves From White Oak

and plants—can feel the coming of Spring. But still the poets have to tell us about it. They tell us about the apple blossoms and the cherry blossoms and the pear

blossoms—fluffy white and glowing pink—about the fragrant hawthorne and every other brilliantly blossoming tree. They commence with April and go right through

Chestnut Oak Leaves

to June, and then when they get to June they can pick up a fresh start with roses. It is all very pretty, only I think they make a great mistake in leaving out the oak tree.

The oak does not make a brilliant show with blossoms; I doubt if you have ever even noticed the shy flowering

sprays drooping among her branches, but the little new oak leaves can play the most wonderful tricks with color as they uncurl and grow. When the leaves of the white oak unfold from the bud they are spread with a silky down which shimmers in the sun with silver mistiness. Day by day these little leaves pass through soft and pearly changes of delicate pink and silvery white until they reach their yellow green maturity.

You may be sure that canny old Mother Nature did not design these oak leaves solely that we might enjoy their beauty. Everything in this living world has its use and does its work, every plant and every lowly animal.

If they are beautiful, as they always are when seen in their proper setting, why, so much the better! And every part of every plant helps to nourish it or protect it, just as every part of you, from your stomach to your skin, is either nourishing you or giving you protection. You know what the bark does for the tree; it does the same thing that your skin does for you, and you know what the rest of the trunk does, and what the roots do. What part do you suppose the leaves play in the life of the tree?

The leaves are the tree's many kitchens, where the raw food—air and sunlight—is prepared for the tree's digestion. When you hold an oak leaf in your hand you can see in it a line running through the center and little lines or veins branching out from the central vein. It is through these veins that the root moisture runs into the leaf, and then, when it has been mixed with the air-food prepared in the leaf kitchen, it runs back again through these veins into the twigs and down through the trunk. When they first told me that the leaves take in air as food for the tree I said, "Yes, but how does the leaf do it? I cannot see any opening in this leaf for the air and sunlight to come in!" "No," they said, "you cannot see any opening, but the openings are there just the same, and the man with the microscope can show them to you any day. If he puts an oak leaf under his microscope

and you close one eye and look through the little glass and listen to what he says, you will see this:”

The leaf has two layers of skin which enclose and protect the veins we noticed with our naked eye. The lower skin is pierced by thousands of openings—tiny holes—one hundred thousand to a space as big as two postage stamps. Through these openings—the man with the microscope would call them *stomata*—flows in that part of the air which the leaf can use. At the same time, water is flowing into the leaf from the branches. In each cell, or tiny living division of the leaf, is a magic fluid which turns the air and water into starches and sugars which the tree can digest. This magic fluid is what makes the leaf green, so we call it leaf-green, but the man with the microscope calls it chlorophyll, a word which he made up from two old Greek words: *chloros*, meaning “green,” and *phulon*, “a leaf.”

Did anyone ever tell you that it is healthy to have green plants in the room? I think you have been told of that, and perhaps you wondered why it was so. The air we breathe contains two important elements; one, called oxygen, is good for us and enters our blood. The other, called carbon dioxide, is a poisonous gas to us and to all animals, but plants live on it. It is made up of carbon and oxygen. Plants’ leaves absorb the carbon, and through their stomata they breathe out the good

element, the oxygen. The animals in their turn absorb this oxygen and breathe out carbon dioxide for the plants. So that plants and animals are both satisfied. This is a very wise and lucky arrangement made by that careful housewife, Mother Nature, who gives plenty to her children, but sees to it that nothing is wasted.

This tree-breathing, this sucking in of carbon and giving off of oxygen which is just the opposite of animal breathing, is called transpiration. In the scheme of Nature this transpiration, or pushing out of oxygen, is a very important process. It goes on all day and all night—but most busily in the daylight—throughout the entire tree; the oxygen passes from cell to cell along the trunk and branches until it reaches the leaves and escapes through the tiny stomata in the leaf skin. If it could not breathe off this oxygen the tree would smother, just as you would smother if you could not breathe off the poisonous carbon dioxide. You see, the tree takes in fifty times as much of this burning sun-power as it can use; if it could not get rid of what was left over, the tree's temperature would rise in a few minutes high enough to kill it. Which is just another way of saying the tree would smother.

Plant breathing is called transpiration, animal breathing is called respiration. You must know, however, that respiration, or breathing off of carbon, goes on in

trees too, but it is a very faint breathing, best observed at night when the sun-drinking chlorophyll is not working.

You know now why your mother sets her pretty potted plants in the window; she wants to give the chlorophyll or leaf-green a chance to catch the sunlight. When it is dark there is just as much plant-food in the air and in the water as when the sun shines, but the chlorophyll needs the heat of the sun's rays to help prepare the air-food and water-food into starches and sugars which the tree can digest. It is the work done by the chlorophyll which makes it possible for us to eat plants and vegetables; we cannot digest air or sunlight, but we can digest them after the chlorophyll has finished working upon them. You see what sincere thanks we owe to the chlorophyll, for from the simple starches, sugars and other foods prepared in the leaf kitchen come all other foods whatever, for animal as well as for plant. It is to the leaf that we must turn to discover the elements upon which we feed and grow; and from which we are in the last testing composed.

That the leaves may catch this life-giving sunlight the forest oak grows tall and straight; its trunk bears no branches lower down where they would be overshadowed by other trees. Have you not seen plant leaves struggling out of the shadow? The ivy spreads itself upon the

sunny wall; the vine creeps up the latticed porch to find the sun. Plant an oak in a broad and roomy field, and its tall trunk will not shoot up bare of branches. Wherever leaves can face the sun, there the branches will grow and spread, and there the leaves will lie in a lacy pattern, no one in the shadow of the other.

The very humblest plants contain no chlorophyll; they cannot absorb and prepare the air-food, but must, like the mistletoe which twines about the oak, fasten themselves upon some other plant, and steal food from their hosts. Such plants—and there are many—are called parasites, from the Greek words *para*, “beside, and *sitos*, “food.”

Why must the tree eat? We know why we need food, we need it to keep our bodies warm. When you are healthy, if you put a doctor's thermometer in your mouth you will find that your bodily temperature is ninety-eight degrees; even on the coldest winter day, when your toes and fingers are numb and your nose as red as an apple, your body temperature will not sink below ninety-eight. The food we eat is the fuel which keeps our bodily fires hot. But a tree has no such high temperature; the tree lives at a low temperature, it moves very little and uses up no energy running about as we do. Compared with an animal, a tree is only half awake, and anything that is half asleep uses up less energy than a running, hunting

animal. If you sprained your ankle and were put to bed for a week, you would not need as much food as you do when you are out rolling snowballs or playing tag.

The tree needs food for two things: growth, and storage. It is during the Spring and early Summer that the leaves do their hardest work, and during those months, of course, the tree has its most rapid growth. In the leaf kitchen is prepared food for the tree to digest right away, and food to store up in the cambium for the nourishment of next year's tender early buds. I think you can see why it is so important for the tree to be able to store up food. When Winter comes the birds fly south to warm countries, bears roll up in their fur and sleep away the cold months in some snug cave, but the oak tree must stay where its roots have taken hold, no matter how fiercely the icy wind may blow. The best way for the tree to protect itself is to pass into an inactive, resting state, to stop growing and go to sleep until the ground thaws. To do this it must first store up food to last the winter and to be ready, as we have said, for the buds when they are stirred to life in the Spring. This power to creep within their own well-stocked fortresses and hold over winter food for their offspring the opening buds and young roots is the power which keeps the race of trees and plants alive from generation to generation.

When Autumn comes the leaf has done its work. The chlorophyll retreats to the woody part of the tree; without its magic fluid the oak leaf turns red, a purplish red which lights the autumn forest in a blaze of glory like the embers of a dying fire. People think the frost turns the leaves to red and gold and purple, but they are mistaken; it is old age which causes autumn foliage. When you are old your skin will wrinkle and your hair will turn white, so with the leaf in autumn when it is old and tired comes a change from the living green. A little cork or stopper forms between stem and twig so that all life is shut off; then the winds of November snatch the dry brown leaf and whirl it in its last wild dance to earth.

CHAPTER V

What People are Made of

When you were a good deal smaller than you are now, and when instead of going to school you played at home in the nursery, perhaps your mother used to say over to you an old rhyme that my mother used to say to me. It was about what girls and boys are made of, and although I liked it very much, it used to make my baby brother quite cross. It went like this:

My mother would say,

“What are little girls made of, made of?”

And I would answer,

“Sugar and spice and everything nice,

That’s what little girls are made of!”

Then somebody, usually one of us children, would ask my brother,

“What are little boys made of, made of?”

He wouldn’t answer at first, but after awhile we would tease him into shouting, all in one breath,

“Snips-and-snails-and-puppy-dogs’-tails,

That’s what little boys are made of!”

When my brother grew up, he went to the Medical School and learned to be a doctor, a student of the human body. It takes ten years of study before they call you a doctor, and do you know, I often think that my brother

studied all those years just so he could find out what he really was made of, and what his teasing sisters were made of!

If someone asked *you* what you were made of, you would be very quick with your reply;

“Flesh and blood and bones!”

But if this curious-minded person went on and asked what your flesh and blood and bones were made of; what would you say then? I know what my brother the doctor would say; he would reply,

“Cells! Living cells!”

And you would shake your head and think he was joking. Why, a cell is a high-walled, narrow room where prisoners are kept—what have stone walls and barred windows to do with the make-up of a human body? “Living cells,” he said. What is a living cell?

A living cell is a tiny piece of clear, colorless jelly called *Protoplasm*, so small you cannot possibly see it without the help of the man with the microscope. In the tiniest drop of your blood some five millions of blood-cells are floating—as many as there are people in New York!

You would think that so tiny a form had no room within itself for anything at all, but let the man with the

microscope put one on a glass slide under his lense, where it will appear about two hundred thousand times as big as it really is. Here is a picture of it.

Cell, with Wall,
Protoplasm
and Nucleus

All around the edge we see a clear line. This is the outer covering of the cell, a kind of skin called the cell-wall which keeps it separate from its neighbor cells. Inside that we see the protoplasm, colorless as white of egg, and somewhere in this is a smaller round or oval speck which is the most important part of the cell; this speck is called the *Nucleus*.

Now, a beautiful and splendidly moving animal such as man, with a brain and five senses, is composed of enormous numbers of cells. A butterfly has not so many, and a jelly fish has fewer still. Swimming about in the water, so small you cannot see them without our friend and his microscope, live animals made of only *one* cell! You can just imagine how small they are, and how simply made. Such a one is the ameba, humblest of all living creatures. The ameba has no arms and no legs, no head and no tail, no eyes and no mouth, no brain and no desires; it is naked, nothing but a nucleus surrounded by a bit of jelly; yet it is able to find food and eat, it moves by stretching itself out and streaming along, and, most marvelous of all, it is able to feel and respond to

certain changes in its surroundings. Put it on a glass slide, then tap the slide sharply, and through the microscope you can see the ameba draw itself up still smaller; bring close to it certain chemicals, and it will come to them or shrink away; strong heat or light will damage it, and electric currents will cause it to move in a particular direction.

Here is a picture of an ameba changing shape and flowing around food. You can see the cell-wall, the protoplasm, and the nucleus. The black spot outside the cell is a particle of plant which the ameba is going to eat.

How Ameba Goes After
His Dinner

See how the ameba goes after his dinner! He has no hands to reach for it, so he stretches out a piece of himself and touches the particle of plant. If it were a stone, or something he could not eat, he would shrink away from it immediately, but somehow this plant seems tasty to him, so he puts out another piece of himself and draws the food right into the protoplasm of his body. He digests as much of it as he wants, and then that clear space you see inside the protoplasm busies itself in pump-

ing out the waste that is left. You can tell it is pumping because it gets larger and smaller and larger and smaller.

The ameba is not the only one-celled form. Every drop of sea water contains millions of such humble creatures; some of them swim along by means of tiny threads which extend out beyond their bodies like the legs of a centipede. They are sea-dust, they are diatom, and sea-dust and diatom serve as food for sea worms. Then the whelk eats the worms, the codfish eats the whelk, and you and I eat the codfish! It sounds like a game, and perhaps it is—Nature's great and fierce and splendid game called the Struggle for Existence. Catch-as-catch-can! Aren't you glad you are not an ameba?

You can readily see why cells are not all the same kind or the same shape. Your hand is not the same shape as your foot, because it has not the same work to do. If all the cells in your body were the same shape and did

the same work, you would be nothing but a glorified ameba! No indeed, your cells are of many, many different shapes and forms. You have gland cells, muscle cells, and nerve cells; cells for growing, moving, and knowing;

and all these different shaped and differently acting cells are connected one with another so that they may work together to make up your living body.

Look at the picture. It is the presence of thousands of cells like Number 1 which enables you to smell. Number 2 is the tiny cell from which a mouse finally grows, and Number 3 is the cell from which a bird finally grows.

Here is the way Mr. Julian Huxley describes the teamwork of the cells—I have changed a few of his words:

“A human body is a huge cell-state, with a cell-population thousands of times larger than the total human population of the world. A single act of thought means the teamwork of a vast multitude of brain-cells, a single movement of a limb sets to work thousands of muscle-cells, a single beat of the heart sends billions of blood-cells whirling down the dark pipes we call blood-vessels. Each of these cells is a unit of life, to be compared to a single free-living cell, such as the ameba.”

When we speak of living tissue, we mean a great mass of these connected cells; a strip of flesh is tissue, the cambium of your oak tree is tissue.

What does the robin do when the time comes for her to multiply, when the time comes for her to make four of herself, instead of one? She lays eggs, and the shells burst, and out of each pretty blue shell comes a baby robin which very soon grows into a mother robin or

a father robin, which in its turn raises a robin family. But what does the cell do when the time comes for it to multiply? The cell, working by itself, cannot lay an egg; it is nothing but a tiny, limbless piece of jelly. Its form is too simple to attempt a task so difficult as building an egg within itself; its form is so simple that there is only one possible way for it to multiply.

It just divides itself in two!

The man with the microscope can tell you all about this. Time after time, he has sat there and watched the cell divide. He has seen one cell become two, and those two become four, and those four eight, and so on into hundreds of thousands. And very thrilling it is to watch, he will tell you! Certain changes take place in the cell, changes that he is familiar with, and which tell him what is going to happen—the cell is about to divide!

Amoeba Dividing

Here is a picture of the amoeba dividing. It was drawn by a lady cell-student, and this is what she says about it. "First of all the nucleus (that is the more solid part on the middle) becomes the shape of the figure 8 its waist gets thinner and

thinner, and soon it divides in two. After that the

rest of the protoplasm also divides, half going round one piece of the nucleus, and half round the other."

Tiny one-celled creatures like those that make up the sea-dust multiply almost too rapidly for our imagination to follow. One of them may become a million in a week, and a quarter million can lie in a gallon of water. In one square yard of lake water there may be, at the height of the breeding season, 7,000 million of them. Perhaps it is just as well that the next largest creatures devour them before they become so many as to choke up the lakes and rivers and seas!

A hundred years ago, when now and again people discovered a new cell, different from all cells they had ever seen, they used to think that this cell came into being all by itself, that it was its own father and mother and grandfather and grandmother. In those days, microscope makers had not learned to make fine lenses such as we have to-day, and it takes a very powerful lense to find out the truth! So men thought a new cell could appear right out of the air, without having any parents at all. Patient men had to spend their lives looking into the microscope to prove that this is not so. No cell appears by itself; every cell was once a part of some other cell, and became an independent cell only when the parent cell divided. An animal is just a great big collection of cells, and you never heard of an animal ap-

pearing out of the clear sky! Every animal is born from a parent animal, every plant from a parent plant, every child from its mother, just as every cell comes from another cell.

You understand, now, how important the cell is. You understand, too, how each of your natural acts—when you breathe, or digest food, or give off waste, or move, or grow—each of these acts, which is shared by all living things, is just your cells expressing themselves in teamwork. Each cell, each mass of cells, is doing the work for which it is fitted.

Each special cell has its own special work, yet there is one thing they all do, one task they are all busy performing day and night, in Springtime and in Wintertime. Just as surely as you breathe, so surely do the cells of your body build up and break down, build up and break down, build up and break down. They absorb food, or water, or air, depending upon what kind of cells they are; they change this food or water or air into something more useful to them, and then they get rid of what is left. They build up and break down, they take in and get rid of, they absorb and give off. I have said it three ways—there are other ways to express it; try if you can think of one; try to say it in your own words. But whatever way we describe it, this building up and breaking down, this breaking down and renewing, is called

Metabolism. And that one word stands for such an important process, such an age-old and meaningful duty performed by the living cell, that I am going to ask you to say it over five times: Metabolism, metabolism, metabolism, metabolism, metabolism!

CHAPTER VI

What Plants are Made of

There is no rhyme which asks what trees are made of. Suppose we make one for ourselves:

What is the green tree made of, made of?

You know very well, in the tree lives the cell;

Cells are what trees are made of, made of!

Yes, trees are made of living cells, just as all other plants are, and just as animals are. Do you remember what we called the jelly-like stuff of which the cell is made? Not such a hard word: *Protoplasm*. Open your eyes and ears now, for I am going to tell you something wonderful.

Plant protoplasm and animal protoplasm are *one and the same!*

All living things come from the same beginning. Has your mother not read to you from the Bible how

“All flesh is grass.”

I never knew what that meant until I learned about protoplasm, and found that animal protoplasm and plant protoplasm are one and the same. To me, this is a very friendly and comforting thing, this thought that all the birds and beasts and flowers and trees began their lives as I began mine. Walking through the fields on some early morning in Spring, have you not had a wild, shy

feeling which told you that you were part of this wide, sweet out-of-doors? Have you not felt as though the leafy bramble before you, the grass under your feet, the thrush singing overhead, were friends of yours, and you understood them, and they you? At such times you have not dared, I think, to pluck so much as one yellow buttercup, for fear of hurting something that is part of you.

And now you know that it is part of you, that we are all one big family, animals and plants and people, because we come from the same beginning, the same protoplasm. Of course, it does not do to make too much of this bond between the animals and the plants; in no sense are the plants related to you as you are related to your aunt or your cousin. It is only in the beginning, the very earliest beginning, before the protoplasm has grown or developed or divided, that plant protoplasm is the same as animal protoplasm. The instant it begins to grow, it takes on special features which mark it for a plant or an animal. Give a cell from a rose leaf and a cell from your skin to the man with the microscope, and he can tell at a glance which is which. That is because they are grown-up cells, cleverly fashioned and adapted for their own special kinds of work. There is one sign which always betrays a green plant cell—chlorophyll, that magic green fluid which absorbs the sunlight. Not one animal in the world

can boast chlorophyll as part of its armor to fight its way through life.

But the man with the microscope can dip from sea water tiny one-celled creatures which he cannot call either plants or animals, because they are as much one as the other. To the animal kingdom and the plant kingdom belong wee free-swimming creatures, mere pieces of protoplasm without a cell-wall, from which whole families of creatures can be traced in both directions—into the animal kingdom and into the plant kingdom.

Dry Empty Wood Cells,
Without Nuclei

The pith of our oak tree is made up of just such cells as these. You can see why the first man with the microscope called them "cells;" they are fitted together just like the cells of a honeycomb.

At the outset, then, our friend the oak tree is the same as any simple, less bulky plant—the same as a violet, for instance. Each commences life as a tiny, naked protoplast (this means a piece of protoplasm) cuddled away inside the parent flower. When the time is ripe, the oak tree cell puts on its protective skin, the

cell-wall. Very soon the cell divides, and the single cell gives rise to a chain of cells and this in turn to a cell-

mass. At first, all the members of this cell-mass are alike, and all do the same work, but as the tree grows larger there is more work to be done, and so the different cell-masses prepare themselves to perform their several duties. Some are set apart for the drinking in of water from the soil; others act as a line of messengers to pass the water up the tree for the nourishment of cell-masses which lie too far from the soil to gather their own water. These messenger cells lie all along up the tree trunk, and they are connected one with another by means of fine threads of protoplasm. Through these threads the sap runs from cell to cell. Still other cell-masses, like those which make up the heartwood and bark, exist only to give bulk and protection to the tree so that it may withstand wind and weather. In the leaf, as you know, are the leaf-cells which contain that magic green fluid, chlorophyll, which uses sun-light to turn air and water into plant food.

And always these cells are building up and breaking down, wearing out and renewing themselves—what did we call this process? A big word, but a short while ago you said it over five times: metabolism. This continues as long as there is life and growth in the tree, which is a long time, because even the oldest tree puts forth new buds and shoots.

The cells, then, do all the work of the tree. So that the most sensible way to study a tree is not to start with root, trunk and branches, but to commence with the cells, to examine each cell-mass and find out how its members do their work. It is only recently that we have learned this best way to study the tree. Formerly, people followed the most natural way, they studied first of all those parts of the tree that looked biggest and most important, the trunk, roots, and branches. It took the man with the microscope to set us straight! He showed us that trunk, roots and branches grow and take shape solely to serve the needs of the tiny cells; he showed us that the well-being of the cells means the health of the tree, and the multiplying of the cells means the growth of the tree. He made us turn our eyes from the bulky trunk to the twigs and leaves, to the root-ends and the tiny root-hairs. These delicate members, he said, are the liveliest parts of the tree; do not think of them as separate forms, but realize that they are just the trunk and branches lengthened out in such shapes that they can bring the living cells closer to the moisture of the earth, closer to the glow of the sunlight. Feeling for moisture is a dainty business, the clumsy, hard-skinned trunk could not do that; its bark is so thick it could not feel the water, and if it could, the water would not soak in. So the trunk

twists itself into roots, and the roots taper out to sensitive ends with delicate root-hairs growing along their sides. It needs a tender surface to drink in the sunlight; the gnarled, sturdy branches could not do this, so they learned to narrow their ends into slender twigs, and the twigs shaped themselves into leaves, flat and thin as paper and green with the sun-drinking fluid they contain.

And all this shaping and changing and twisting has just one aim in view; the welfare of the cells. Now you no longer wonder why the man with the microscope told us that if we wanted to know the tree we must,

“Study the cell!”

CHAPTER VII

The Meaning of the Flower

“There’s rosemary, that’s for remembrance;—and there is pansies, that’s for thoughts.”

Shakespeare’s Hamlet, Act 4, Scene 5.

The earliest nations had a flower language; they left traces of it in the flower-writing and flower symbols on the tombs and monuments of ancient Egypt and Assyria. We can only dimly guess at the meaning of these flower drawings, but we can understand the flower symbols of another people, the Greeks, who were so passionately fond of flowers that they turned naturally to them whenever they had some deep feeling to express. In the soft airs of that ancient country, lovers hung the doorways of their sweethearts’ homes with garlands; when someone inside the house was ill, their friends knew of it by the blackthorn and laurel which lay across the lintel. In fetes and festivals the young men crowned themselves with flowers; blossoms brightened the city gates in times of rejoicing.

Perhaps you have eaten Thanksgiving dinner at your uncle’s house, or watched the Christmas turkey carved at your grandfather’s table; when the plum pudding came on and the cider was passed, you would have been sur-

prised, no doubt, if your father and uncle and grandfather had placed wreaths of roses on their heads! Yet that is what the fathers and grandfathers of Greek boys and girls did when they feasted in the homes of their friends, and everybody thought it a very pleasant custom. In the Grecian games, too, the winning athletes were crowned with laurel leaves; those were proud mothers who saw their strong sons, wrestlers, runners, throwers, come forward and bend their heads to receive the victor's wreath.

Oak leaves were twined to weave the patriot's crown, bay leaves for the poet, and myrtle was the crown of beauty. The highest honor for which a Roman soldier longed was the civic crown of oak leaves, because it proved to all men that he had braved death in the service of his country.

Every nation has its favorite flower; India has her lotus, Japan her chrysanthemum. The Hindus believe that their God, Brahma, was born a tiny baby in the bosom of a lotus, and so they hold the lotus sacred. The Parsians celebrate every year a "feast of roses," lasting as long as the roses bloom. You know the flower of France, do you not, the fleur-de-lis? When Napoleon was emperor, he ripped the lilies from the royal robes and in their stead caused golden bees to be embroidered, but when Napoleon's majesty had passed, the fleur-de-lis

found its way back upon the royal robes and upon the shield of France.

More than a hundred years ago, when the city of Berlin was filled with Napoleon's victorious soldiers, Louise, mother of the German Emperor William I, was forced to take refuge with her family on the outskirts of the city. When the children of the city cried because they were hungry and had no shoes to cover their feet, the Queen-mother, to comfort them, gave them garlands woven from cornflowers which she had gathered by the wayside. Since that time the cornflower has been Germany's favorite.

In your history books you have read about the Wars of the Roses, fought between the English lords of Lancaster and of York. The family of Lancaster wore the red rose, their enemies, the white rose. Not until a daughter of York married a son of Lancaster did the terrible feud end, and then England took for its flower the Tudor Rose.

Perhaps you know the story of the shamrock. One day when Saint Patrick, patron saint of Ireland, stood preaching out-of-doors, he could not make the simple country folk understand the meaning of the Trinity. They frowned and asked,

"How can there be three Gods, and yet one God?"

The Saint gazed about him in perplexity; he looked up, and he looked down. Then, stooping, he plucked a shamrock growing at his feet and held it up before the people.

"Do you not see," said he, "in this wild flower, how three leaves are united on one stalk, and will you not then believe what I tell you, that there are indeed three persons and yet one God?"

The people understood, and from that time the Shamrock has been the national flower of Ireland.

A thousand years ago, when a gentleman had no business but to fight, the Danes came down from the north to conquer Scotland. On the eastern-most point of that country stood a strong castle, walled and moated. One dark night, when the Danes had made all ready, they took off their shoes and crept stealthily upon this castle, expecting to swim across the moat. Suddenly the air resounded with cries of rage and distress; not a man but longed for water,—the dry moat was filled with thistles! Inside the castle the men-at-arms were roused, and Scotland was saved. Out of gratitude for their escape, the Scots adopted the thistle as their national emblem.

Every loyal Welshman wears a leek in his cap upon Saint David's Day. In the year 640, on Saint David's Day, the Welsh were about to march against an English army. In those times, every army did not have its own specially designed uniform, as it has now, so to dis-

tinguish themselves from the enemy the soldiers wore such badges as they could obtain, As they marched through a field, every Welshman plucked a leek and stuck it in his cap. The Welsh won the battle, and in grateful memory of the victory they kept the leek as their national flower.

On the Mexican shield is pictured an eagle perched upon a cactus stem. After the Aztecs had wandered many years they met a wise man, who told them,

“Where you find an eagle perched upon a rock, there shall you build your city.”

As they drew near Lake Tezcucó, they spied an eagle perched upon a cactus branch which grew upon a rock. They rejoiced, because they were tired of roving, and there they stayed and built their city, which they called by a name meaning cactus-on-a-stem.

Our own country has no national flower, but almost every state has its favorite. Maine has the pine cone and tassel, Nebraska the goldenrod, Kansas the sun-flower, California the poppy. Many states have asked their school children to select a flower for them. Which flower would you choose for your state?

The rose has always been the queen of flowers. To the ancients it was the emblem of silence, love and joy. At great feasts they would hang a rose over the table to remind the guests that the talk must not grow too

loud; it must be "sub rosa," meaning "under the rose." In the language of flowers, a single rose means, "I love you." The wallflower stands for love faithful in spite of adversity, the daffodil for unrequited love, the dandelion for coquetry, the honeysuckle for devotion, the goldenrod for encouragement, the forget-me-not for true love. So well do the eastern nations understand the language of flowers that a Persian girl, receiving a bouquet of blossoms, would have no need of words from her lover. If she found there a snowdrop, she would know that she had a friend in need, a hyacinth would betoken that her lover was sorrowful. Perhaps she would return to him a moss-rose bud, her confession of love.

Good luck follows the finder of a four leaf clover, good fortune comes to him who spies white heather. Lilies for Easter time, holly and mistletoe for Christmas, orange blossoms for the bride—how closely flowers are woven into the happiest days of our life!

All these things, and more, the flower means to us; now let us see what the flower means to the plant.

What do you do when you want to plant a tree? You plant a seed! And where does the seed come from? The fruit of the tree, be it juicy apple or hard, dry acorn. And what makes the fruit? The flower! So it is the flower that plays the part of reproduction, and re-

production, in Nature, means reproducing or creating others like yourself, whether you be a tree or a stalk of wheat or an Easter lily.

In the last chapter, on cells, we asked,

“What does the cell do when the time comes for it to multiply?”

The answer was,

“It divides in two.”

But we left another question unasked,

“How does the cell know when the time has come for it to multiply?”

The ameba knows because it is getting too big; its growth is inconvenient to its simple structure, and it must check growth by splitting in two. In one-celled creatures like the ameba, division always makes two creatures where there has been one, but in a many-celled form like the flower, cell-division does not make two flowers, it just makes more cells for the one flower so it can grow bigger and brighter. The flower is higher in the scale of life than the ameba, it is composed of thousands of cells, and because it is so formed, a special thing has to happen before it can give birth to a new flower. Indeed, this special thing has to happen to a rose or a lion or a pussycat or a human being before they can make two of themselves. Before it can divide the

cell must be touched and wakened by another cell, and for flowers this other cell is contained in the pollen of another flower of its own kind. And so:

The flower cell knows its time has come *when the pollen touches it*.

Let us examine a buttercup, and see how the whole flower is designed for this business of pollen shedding and pollen receiving, this business called pollination.

On the outside are five or more green scales, like leaves. They form the calyx, which protects the fragile inner parts of the bud, and, as the bud opens, steadies the flower. Next come the bright yellow petals of the

Buttercup Cut in Half

corolla, and inside the corolla are the pollen-bearing stamens. In each stamen the pollen is held in a sac at the end of a stalk; the sac is called the head, or anther. In the center of the flower are many small green grains, the carpels, and in each carpel is an ovule containing an egg-cell. The part of the carpels containing the ovule is called the ovary, or seed-vessel, because it is the ovules which will one day, when the pollen reaches them, become seeds.

It is puzzling, after one has learned from a buttercup the four parts of the flower,—calyx, corolla, stamens

and carpels, to try to find them in other flowers. In many flowers, two parts will be combined, so that you can

Father and Mother Catkins of the Oak

find only three of the sections. In the Easter lily, for instance, the green calyx of the bud becomes the waxy white corolla of the flower. The carpels are united to form one long pistil; you can see it thrusting itself out beyond the yellow stamens. Many flowers, again, do not possess both pistil and stamens; in this case the flowers may grow in pairs, as the flowers of the oak. The male or pollen-bearing flower containing the stamens is called the staminate flower, the female or pollen-receiving flower containing the pistil is the pistillate flower.

Staminate Flower

Pistillate Flower

There they hang from the bough, mother and father catkins of the oak, side by side, waving gently in the breeze. The pollen-bearing flowers droop like so many beads on a string, several strings hanging from the same point, fringe-like; all flowers which grow like that are called "catkins." The mother flowers, the pistillates, hide shyly up under the axils of the leaves, just where you

will find the acorn when the flower is gone. It is early Spring, the foliage leaves have just unfolded, in the staminate flower the pollen is ripe. A puff of wind shakes loose the pollen grains, they are blown against the pistillate flowers, the sticky surface of the pistil catches them, and the business of pollination is under way.

When the cell in the pollen meets the egg-cell in the pistil, Nature knows that one important piece of business is done. The egg-cell is *fertilized*, and right away it begins to grow and divide. It has in it, now, the character of both its parents; let us see what it will become.

At first it is nourished by food stored in the embryo-sac, food something like white of egg. The embryo develops into the seed; the bright petals of the corolla, no longer needed now, wither away; when the seed is ripe growth stops, the young tissues dry up and your acorn is cast loose from the parent tree. The reason the young tissues dry up is so that the acorn may rest without food until it is planted and can gather food for itself.

Now you understand what Mr. J. Arthur Thomson meant when he said,

“Trace an oak tree to a sapling, to a seedling, to a seed and an ovule, and we come to a fertilized egg-cell, the beginning of individual life.”

CHAPTER VIII

The Bee and the Flower

Hidden in the pistil, the egg-cell waits for the sperm-cell in the pollen of *another flower*, to come and wake it into growth.

On the oak branch, as we have seen, the pistils and stamens grow in separate flowers, no one flower containing both male and female cells. But with most garden flowers this is not the case. Al-

The Humming Bird Gets Her Supper

most every flower which you admire holds in its bright corolla both pistil and stamens. It is so with the buttercup and with the rose, with the poppy and with the mignonette.

Why is it, when the rose contains both egg-cell and sperm-cell, both pistils and stamens, that the egg-cell must wait for the pollen of *another flower*? Why does not the pollen from its own stamen-heads fall upon the pistil and go about its business of joining with the egg-cell? In other words, why does not the flower fertilize itself?

Because, as Charles Darwin said—and he was the greatest nature student of them all—

“Nature hates self-fertilization.”

Has your father a garden? Then he can tell you how cross-fertilizing with fresh stock makes his flowers stronger and prettier. Perhaps he has given you a flower bed all your own, to dig and cultivate for yourself. Suppose you plant in your bed two red rose bushes, side by side. Then suppose you arrange things so that the flowers of one of these bushes receive no pollen but their own, whereas the roses on the other bush receive pollen from a third bush. The first June, both bushes will bear like flowers, perhaps they will flourish equally well for several generations (a generation for a rose bush means a year), but in the end the self-fertilized bush will become sickly and weak and will be crowded to death by the fresh strength of the cross-fertilized bush.

Because Nature knows the dangers of self-fertilization, she takes measures to prevent it. In a flower containing both pistil and stamens she does not allow pistil and stamens to ripen at the same time, she sees to it that the pollen ripens and is carried away before the pistil is ready to receive it. The latter, then, must wait for the pollen from some other flower. Or, when pistil and stamens are bound to ripen at the same time, Nature twists the stamens out of reach of the pistil. In both

cases, you see, Nature gets what she is after; cross-fertilization.

Of course, self-fertilization is better than none. Knowing this, Nature has devised means for self-fertilization in case something interferes to stop cross-fertilization. Violets, for instance, have some late buds which never open, but pollinize themselves inside the bud. Flowers which grow in the water and cannot reach the surface, like the water buttercup, are forced to self-fertilization. There are many examples of flowers which pollinize themselves successfully, but for the most part, Nature gives her children the benefit of inheritance from fresh stock.

You know what "inheritance" means, do you not? Perhaps you have blue eyes, but you think brown eyes prettier. Then you had better marry a brown-eyed girl when you grow up, so that your children may have a chance to inherit her brown eyes. Or perhaps you have red hair and freckles, and there hangs on your dining room wall at home an old portrait of a young lady with red hair and freckles—of course the artist did not put in the freckles, but you have good reasons to know they were there.

"Yes," you have heard your mother say, "Mary inherits her red hair from Great-grandmother Babcock!"

To inherit means to receive by nature from one's ancestors. If you want to get that red hair out of your family—which I think would be a mistake, because red hair is beautiful—you must be sure to marry a black haired gentleman, like Mr. Mantilini in Dicken's story of "Nicholas Nickleby."

Sometimes these family traits are so stubborn they will not be subdued, but crop out at the most unexpected times after skipping a generation or two. Perhaps you have seen pictures of the Spanish kings, Philip Second, Third and Fourth. Because they were kings, and rich, artists were eager to paint their portraits. A wonderfully skillful artist named Velasquez, a Spaniard, painted Philip the Fourth's portrait forty times! And yet, if Philip had not been a king, I doubt if Velasquez could have been bribed to paint him, because he was so homely. He had a long nose and a still longer chin, and his ugly thick under-lip protruded in a perpetual pout. Poor Philip the Fourth! He couldn't help that heavy lip, he came by it naturally from his Austrian forebears, the Hapsburgs, and in the Hapsburg family that lip was so persistent in its reappearance that it is still known as the "Hapsburg lip."

There are some very queer kinks in this business of inheritance and cross-fertiliation. Things don't always work out the way they are expected to. For instance, if

you cross-breed a black bull with a red cow you will not get a roan or mixed calf, but a black one like its father. Certain colors, such as black and white, seem to be more persistent, more powerful than other colors; these colors are said to be "dominant" over the others. On the other hand, animal and plant breeders can often take two very unlike parents and obtain offspring which are perfect blends of their parents. In crosses between long-eared rabbits and short-eared rabbits, a learned professor found that the baby rabbit's ears were neither long nor short, but halfway between. Many plant hybrids (children of parents of different plants) are very exact blends of their parents. The natural color of a wild rabbit is grey. If the breeder crosses two tame rabbits, a black father rabbit and a white mother rabbit, he will soon have a little baby rabbit the color of its faraway wild *grey* ancestor. Living creatures will always return to their wild state if they have a chance, and this baby rabbit had a chance because black and white contain all the pigments necessary to make up the color grey.

It is the nucleus of the cell that carries red hair or lop-ears or white fur or long chins from generation to generation. When the sperm-cell of the black rabbit met the egg-cell of the white rabbit, it was decided then and there what color fur the baby rabbit would have. When after fertilization the egg-cell grows and divides, the

nucleus grows and divides too, so that every cell in your body, muscle cell, brain cell, eye cell, hair cell, has in it, in a sense, a bit of the original egg-cell from which you came. It will set your imagination spinning to realize that everything you now are comes, with the aid of nurture, from that one first tiny bit of protoplasm.

The story of inheritance and cross-fertilization is so fascinating and so useful to mankind that men have spent their lives at it. Out in California our own countryman, Luther Burbank, has acres upon acres of flowers and vegetables and fruits, all new varieties which he has created by careful crossing and hybridizing. He has grown beautiful plums and berries, bigger and juicier than any plums and berries ever tasted before, and he has done this by carefully selecting and cross-breeding or hybridizing those fruits which he knew would have healthy children. He took a dewberry and a raspberry and crossed them, and next season, up came a new berry—he called it “Primus”—which ripens before most blackberries and raspberries even commence to bloom. He laid the pollen from a staminate blackberry upon the pistil of a Crystal White berry and after patient waiting he found upon the bush the most beautiful snow-white berries, so clear that he could count the small seeds within them. These he called “Iceberg” berries. He grew seedless prunes and fragrant pansies—you know most

pansies have no scent at all—he grew deep-colored roses, great enormous daisies, double clematis, wide petaled poppies, and a host of lilies never seen before.

“Can my thoughts be imagined,” wrote Burbank, “after many years of patient care and labor (he had been working over sixteen years) as, walking among my new lilies on a dewy morning, I look upon these new forms of beauty, on which other eyes have never gazed? Here is a plant six feet high, with yellow flowers, beside it one only six inches high with dark red flowers, and further on one of pale straw, or snowy white, or with curious dots and shadings; some deliciously fragrant, others partly so; some with upright, others with nodding flowers; some with dark green, woolly leaves in whorls, or with polished light green, lance-like, scattered leaves.”

Burbank strolls along his garden walk, pausing here and there to enjoy the fragrance of some lovely blossom. At the turn of the path he comes upon a clump of Sweet William raising their modest heads alongside the tall, graceful stems of a bed of white carnations.

“What a rare combination that would be,” thinks Mr. Burbank, “Carnations and Sweet William! I believe I’ll try it!”

So from the Sweet William he cuts away the stamens before the pollen is ripe enough to fall, and he ties up the flower in a paper bag so that no other pollen can reach

it. When the pistil is ripe he takes off the bag and places upon the pistil pollen from his carnation. After which he shuts the flower up again in its bag until the seed begins to form, and there he has the seed for a new flower!

That is the way Luther Burbank does it.

Now let us see how Nature does it, let us see what messengers Nature uses to carry the pollen from flower to flower, and so effect cross-fertilization.

She uses the wind, and she uses insects.

She uses bees—bumble bees and honey bees—wasps, and flies, and beetles. She uses insects that crawl and insects that fly, snail and moth, ant and butterfly, the homely slug and the gorgeous humming-bird. All these insects, and countless others, visit flowers in order to eat

Bee Rifling Flower

the pollen or the honey they find there. The bee lights upon the violet petal and pushes his trunk down the nectar pouch to taste the honey; as he does so he gets his back dusted with pollen from the stamens above. He

flies away, and on entering another violet he rubs the fine yellow grains off upon the pistil which opens to receive them, and the flower is pollinated. Or, hovering

over a buttercup, preparing to rifle the nectary at the base of each golden petal, the pollen catches on his feet and he wipes it off upon the pistil of the next flower, just as your little brother, when he forgets himself, wipes the mud from his boots onto the parlor rug!

Pollen is the only food for bees, wasps, flies, beetles, moths and butterflies, so you can see what a happy arrangement Nature has made; the insects are fed, the flowers are cross-pollinated.

Eagerly the flowers await their insect visitors. See how dainty Miss Poppy puts on her very prettiest dress to attract her butterfly friend! How sweet the fragrance of the rose as, laying back her glowing petals she offers her pollen to the bumble bee! Brilliant color draws the insects; that is why the corolla flames scarlet, blue or yellow. Naturalists have differed as to which has the stronger attraction, bright color of the corolla or sweet scent of the nectar. Darwin thought it was the color, so to make sure he stripped the bright petals from his flowers, and no insects approached them. But Plateau, a Belgian naturalist, was not satisfied with this proof. He said to himself,

“Mr. Darwin was careless when he took the petals from his flowers, he handled them roughly and injured them,—that is why the bees would not come. Now I will strip the petals very, very tenderly from my brightest,

showiest flowers, my gay blue larkspur and my purple foxglove, and I can wager that the insects will not desert my flowers."

So Monsieur Plateau did as he had planned, and saw the insects come crawling and flying to his shorn flowers; indeed, the bees not only sucked the honey, but they circled around and above as though the poor naked blossoms were flaunting their loveliest dresses. So he knew the insects were guided more by the scent of the nectar than the color of the corolla. Plateau also noticed that some of his gayest flowers were totally avoided by insects, but when he placed nectar at the base, insects flew to them eagerly. Of course, Plateau did not decide from this that color played no part in attracting insects; Nature, he knew, never created all those gorgeous petals for no other use than beauty; he watched the white butterfly light upon the white spirea and the yellow butterfly seek out the golden bloom, but he knew that the beetles and bugs and flies—which after all do a bigger pollinating business than the bees and butterflies—are attracted solely by scent.

Special gland-cells in the flower produce the nectar, and all plants with nectar have an odor, although we with our clumsy nostrils blunted by disuse may not be able to smell it. Flies, you know, are not very clean creatures, they are often attracted by unpleasant odors;

there are dull yellow or brownish flowers which draw their insect visitors by giving off the putrid odor of decay. Have you white flowers in your garden, such as the slender-stemmed tobacco plant? At night these flowers glow in the darkness, and their scent steals upon the summer air until the white moths flutter to them. On Easter day a friend brought to our house a lily with seven blossoms; all day we could not catch a trace of odor though we pressed our faces close to the great waxy petals, but at night the room was filled with fragrance, a fragrance so sweet it followed us upstairs when we put out the light at bed-time.

Many flowers expose their pollen only in the brightest sunlight; it is at noon of the sunshiniest days that the bees buzz loudest. Because the fine working days are far too few, the bees must make the most of their time, so they go about their pollen gathering in a very business-like way. Mr. Bee starts on one kind of flower, say a honeysuckle blossom; he learns the quickest and shortest way to the nectar, and when he has sucked it dry he flies to another blossom on the same vine and another and another, each time, perhaps, obtaining his prize with more ease and swiftness. The flowers, too, help to save time; many of them change color and fade as soon as fertilized. It is their way of saying to the bees,

“My honey is already gone, so don’t come buzzing round wasting your time on *me!*”

Often the anthers change color too; the anthers, you remember, are the pollen-sacs on the ends of the stamens. Most anthers are yellow, but if you search you can find differently tinted ones, red in the peach blossom, dark purple in the poppy and the tulip.

CHAPTER IX

How Nature Created the First Plants

Away back in the beginning of the world there were no bees nor humming-birds; there were only cockroaches and locusts, crawling insects that fed upon dead leaves and leafy plants, or swam in the water and lived upon the water-bugs. It took Nature millions of years, perhaps, to create a plant that could produce honey for the bee, and until the pollen flowers came there were no bees, no flies nor beetles, no moths, ants nor wasps.

You see, Nature did not create the rose all in one minute; she did not just snap her fingers and say, "Rose, come up!"—and the rose bush sprang up shining with flowers. Millions of years ago Nature began to create the rose bush, and when she began she was not at all sure how it was going to turn out. She took what materials she had and with skillful fingers she shaped a simple green plant which bore no flowers, and so, of course, no seeds. The egg-cell and the sperm-cell were exposed loosely on the leaves, as they are to-day on the humbler plants, such as the ferns and mosses. Nature watched this plant for a million years, and she was not satisfied with it. She said to herself,

"H'm, that is a clumsy way for my rose-plant to bear little ones; I can think of a better way than that!"

So she put her gentle hands upon the leaves and patiently, through hundreds of generations, she twisted them and shaped them and colored them until they became—what?

Calyx

Corolla

Stamens with pollen inside them, and

Pistils to receive the pollen.

In all this shaping and changing Nature had one end in view, a better scheme for the transfer of pollen, a better device for the scattering of seeds.

Nature's slow work of transformation, whether we speak of plants or animals, of roses or oak trees, is called *Evolution*. Every plant and every animal has grown or *evolved* from some much simpler form, but it has taken centuries to accomplish this evolution.

Plants had leaves before they had flowers, and all parts of the flower except the stem are transformed leaves. Look at one of those great white peonies growing by your garden gate, you can easily see where the green leaves become bracts of the calyx, and the bracts become petals of the corolla. Have you ever seen double peonies? The gardener made them that way by cross-fertilization; the extra petals are merely transformed stamens. Next summer, as you paddle your canoe across the still waters of the pond, pull a white

water lily, a wide-open one, and you can trace clearly the change from stamens to pistil. Indeed, when you know all about the flowers you can trace every part, from calyx to corolla to stamen and pistil, back to the green leaf. Even the anther on the stamen is an unfolded leaf-blade.

So, you see, "all parts of the flower have a common nature—they are all leaves transformed in various ways and combining to fulfil the plant's chief end—that it should produce seeds which will develop into full-grown plants and bear next year's flowers."—Arthur Thomson. All the features which make flowers different one from another, color, form, and fragrance, are due to Nature's efforts to secure the best possible means for the transfer of pollen.

Because they are wind-pollinated, not insect-pollinated, the flowers of the oak are small and modest. The corolla is not formed to attract notice, so it is not vivid nor large, if so it would be a hindrance, catching the flying pollen and preventing it from reaching the sticky surface of the pistil. On most wind flowers the stamens hang far out of the corolla on slender threads, "dangling in the air, shaken by every gust." The pistils, too, protrude; have you never watched the hazel catkins swinging in the breeze, their crimson pistils combing the air for drifting pollen? In wind-pollinated plants the flowers

open early in the Spring, before the foliage leaves grow big enough to interfere with the flight of the pollen. Wind-borne pollen is light as dust, and Nature has to provide plenty of it, for a single grain flying on the wind has a very slight chance of finding the pistil of a flower of its own kind. In the pine tree Nature has made for each pollen grain two little bladders the better to float in the air.

There is wind-borne pollen and there is water-borne pollen; the grasswrack of the sea, the weeds in the mill-pond depend upon the water to carry their pollen from plant to plant, and Nature shapes their flowers so that wind and water may serve their pollinating purpose easily. And all the time our insect-pollinated flowers are doing what they can to attract their winged or their crawling friends. Have you ever seen a barberry hedge, with its red berries nodding their jolly little heads at Christmas time? The barberry flowers are so eager for cross-fertilization, so afraid the pollen grains will escape them, that their stamens spring forward and close over anything touching the inside of their base. Where a flower has no corolla, the calyx, after the bud has unfolded, often takes upon itself the form and duties of the corolla. It becomes brighter in color, its petals grow silky to the touch, like the marsh-marigold and purple

clematis. If it remained a dark, thick green calyx, fit only for protecting the bud, the bees would not fly to it.

And not only does the flower put on her fine dress and sweet perfume to attract the insects, she also does what she can to make things comfortable for these visitors when they alight. She stiffens her petals to make strong landing-stages for the bees; in the lady's slipper you can see how the petal has thickened just where the insect has to stand, so also in the orchid, the purple sage, and the golden broom. A flower like the hedge-parsley holds its nectar in a shallow cup, so that flies and such short-tongued insects can easily reach it, and flies wander about over the blossoms scattering pollen freely. "But in a flower like the sage," we are told by our old friend Mr. Arthur Thomson, "the nectar is hidden at the bottom of the deep corolla tube; it can be reached only by long-tongued bees," and Mr. Bee must enter the flower in one particular way. The lower petal forms a landing-stage to which Mr. Bee clings; he thrusts his head and little chest into the corolla tube. As he pushes against the lower ends of the two stamens, the upper ends swing down and dust his back with pollen. He buzzes off to another sage flower, a somewhat older one this time, whose pistil raises its head from the upper petal just far enough to get in Mr. Bee's way and catch the pollen from off his back. Such a flower as the sage has all its parts

shaped so that nobody can carry its pollen except Mr. Bee. If Mrs. Fly attempts to enter in search of nectar she soon finds she is not strong enough to push against the heavy stamens, and even if she succeeded in getting by them, she would be stopped half way down the corolla tube by a fence of stiff hairs which the sage has put up on purpose.

If Nature works over each flower until it has that color, scent, and structure which best adapts it for insect visitors, she also works over the insects, that they may be better fitted to gather pollen or to suck nectar from the blossoms. Flower-visiting flies and beetles have long, sharp noses and pointed jaws wonderfully adapted for scraping pollen from the anthers of flowers. Growing out from under his jaw the humble-bee has two long, strong spikes with which he can pierce right through the petals of such flowers as wisteria, clover or forget-me-not, reaching the nectar by short-cut. The honey-bee, which has shorter spikes, cannot pierce the corolla, but must crawl partly into the flower from one side, and has a hard time finding the nectar.

If you want to have strong muscles in your arms, what do you do to gain them? You throw your ball, you learn to pitch straight and true, you exercise the muscles by using them, and the more they are used, the stronger they grow. Violin players have strong wrists and fingers,

laborers who dig all day with a shovel have strong backs and shoulders, mountain climbers have legs as hard and springy as wire. So with the insects, perhaps the simple exercises of probing for honey, of gathering pollen, repeated day after day, hour after hour, have developed and created bees, certain flies and beetles, and all the moths and butterflies.

How closely, then, the flowers and insects are related! If all the bees should die, our porches would soon be bare of honeysuckle; without flowers the butterflies would starve. Flowers and insects depend one upon another, and in their dependence we can see one more strand, the strongest strand, of that great web which knits us all together—earth and air, soil and water, plant, animal and man—Nature's Web of Life.

CHAPTER X

The Web of Life

In Mr. Arthur Thomson's big red book, "The Outline of Science," there is a beautiful colored photograph of a spider's web, with old Mrs. Spider squatting in the center on the watch for silly Mr. Fly. Old Mrs. Spider does not always stay on her web, she often hides in a

nearby shelter, but she has a signal which tells her when she has caught her dinner. A special line runs from the web to her den, and when this line shakes she knows the web is shaking with the weight of her victim. Like the fisherman with a taut line between his fingers, Mrs. Spider can tell by the strength of the pull whether her

catch is a fierce big wasp or a delicious little insect, and she knows whether to stay safely where she is or to scramble out and seize upon her prey.

Her web is beautifully planned; it is woven in and out and round about upon a scaffolding which she afterwards removes; every silken thread is related to every other thread, and because of this relationship and this completeness, Mr. Thomson uses the spider's web as a symbol of the web of life—woven by Mother Nature in and out and round about among her creatures so that nowhere a link is missing.

“No creature lives or dies to ~~it~~self. All are linked to other lives, often in unsuspected ways.” The most important linkage in the world is one of which we have been talking, the linkage between flowers and their insect visitors. Charles Darwin has a story to tell about this; it is called his “cats and clover” story.

“Round a hundred heads of the purple clover Darwin put muslin bags so that air got in and sunlight got in, but no insects. From these hundred heads he got not a single real seed, while from another hundred heads without muslin bags he obtained 27,000 seeds. These heads had been visited by the humble-bee, which effects cross-fertilization. So the more humble-bees the better next year's clover crop.

But the nests of the humble-bees are rifled by the field-mice, which are fond of the delicate white grubs (the children of the humble-bees). Therefore, the more field-mice the fewer humble-bees, and the poorer next year's clover crop.

But in the neighborhood of villages there are fewer field-mice than in the open country, for the cats hunt them down, killing them though they do not eat them. Therefore, the more cats the fewer field-mice, and the fewer field-mice the more humble-bees, and the more humble-bees the better next year's clover crop. And so, the more clover the richer pasture for the cattle, and the more roast beef for John Bull (or Uncle Sam!). The more kindly old ladies there are in the village the more cats there will be, and this again will favor the clover!

Thus cats and clover and cattle are linked together."

We have seen that besides carrying pollen, birds and insects help to scatter the seeds made from the pollen. The thrush picks the berries from the mistletoe; he sits upon the oak bough to enjoy his feast and when he comes to a seed he wipes it neatly from his bill onto the branch. As the juice about them dries, the seeds stick fast to the branch until next Spring, when they begin to grow just where they are!

The mistletoe, as you know, is a parasite; it cannot feed itself and so it lives upon the mother oak. Many

plants live thus upon each other, and many animals also. In Mr. Thomson's big red book you can read about the habits of these lazy parasite plants and animals, about the barnacles that grow in the crab's shell or the tiny pea-crab that lives within the horse-mussel. There is the horse-mackerel that sometimes swims about under the shelter of a big jellyfish's umbrella, and there is the pilot-fish that swims by the side of the shark. But perhaps the most striking partnership of all is that of the zic-zac and the crocodile.

The Zic-Zac and the Crocodile

The zic-zac is a lively little bird that lives in Egypt upon the banks of the broad, green Nile. It has a shrill

voice which carries a long way, and whenever danger approaches, whether of beast or man, this excited little bird sends out a warning cry so that his sluggish lazy friend the crocodile may slide under the mud out of danger. The zic-zac perches upon the crocodile's back and picks off leeches to eat; sometimes he will even snatch a piece of food from between the reptile's teeth! A traveller tells how the zic-zac, "in searching for the leeches, finds its way into the reptile's mouth while the latter is basking on a sandbank, where it lies generally with the jaws wide open. Once in a while the crocodile falls asleep, when the jaws suddenly fall, and the zic-zac is shut up in the mouth. It straightway prods the crocodile with its horny spurs, as if refreshing the memory of his reptilian majesty, who opens his jaws and lets his favorite leech-catcher free."

It is a far cry from our oak tree to the zic-zac on the banks of the Nile, but I want you to see how all over the world Nature's web of life extends, linking animal and plant and earth and man. There are plants which move almost as though they were urged by animal instincts; Pimpernel, the Shepherd's Weather-Glass, closes its petals if the sun goes behind a cloud. If you stop a moment I am sure you can think of a flower which "goes to sleep" at night. Flowers do not really go to

sleep, they have no need of sleep,—nor would you if, like the tulip, you remained all day waving gracefully upon a stalk! Perhaps the flowers close to keep warm on cold nights, perhaps they try to avoid the dew, or maybe they want to save their pollen from being spoiled by rain in wet weather.

The only movement which most plants can make is this closing of their petals when the dark comes, but in tropical countries there can be found a prickly shrub the leaves of which close when touched. For this reason it is called the Sensitive Plant; it grows a few feet high, bears purple flowers, and people like to cultivate it in hothouses to watch the leaf stalks droop and the leaflets fold up the minute it is touched. We do not know exactly why the Sensitive Plant has this power of movement, it does not frighten away browsing animals or other enemies, and repeated movements seem to tire the plant so that it becomes stunted in its growth, like a growing boy who is forced day after day to overwork his heart or his muscles.

There are other plants, however, to which the power of movement means a great deal—it means their dinners and their suppers! Not all plants live upon air and water like the rose, or feed upon their host as the mistletoe feeds upon the oak. Some plants live upon insects, and these they catch and kill by means of leaf movements.

American Pitcher Plant

Down in the warm Caroline Islands, when careless Mrs. Fly touches one of the sensitive hairs upon the leaf of the plant called Venus Fly-trap, the two blades of the leaf snap together and Mrs. Fly is soon crushed, drowned in the sticky fluid and digested! Over in England Mrs. Fly must avoid the Common Sundew, or she will be caught in the sticky fluid of the leaf gland which will then fold over her and imprison her. In our own land the insects must be no less wary, or they will perhaps fall into the leaf pitchers of the Pitcher Plant and be drowned and digested like their brothers in Cochin-china!

So you see that although a few animals and plants help each other, most of them are much more ready to devour their neighbors than to help them. This fierce and never-ending struggle for life is not a wicked design of Mother Nature's; on the contrary, it is what makes certain families of plants, certain kinds of animals, certain races of men, grow stronger and more beautiful from generation to generation. With so many enemies to fight, only the strongest, the cleverest, the best adapted can win the battle for life.

In the beginning, perhaps the rose had no thorns, the cactus no needles, the adder no sting. Likely enough, the first giraffe had a neck no longer than a pony's! But as the centuries advanced, the rose and the cactus, fearful of the trampling hoofs, the greedy jaws of wild

Venus Fly-trap

animals, developed their horns and their needles; the adder with the deadliest sting lived longer and laid more eggs than her stingless sisters; the giraffe with the longest neck could reach higher leaves upon the tree in time of drought or famine when his shorter-necked brothers were starving because the pasture had burned dry with the sun.

Plants and animals and men must struggle against disease, against attacking animals, against climate. The polar bear protects himself from the cold by growing thick, heavy fur; the African's skin is dark so that the sun cannot burn it. Man, seeing the warfare that goes on forever among the creatures beneath him, often tries to turn this struggle to his own advantage, sometimes with success, often with failure. To kill the tent-worm, he brought the English sparrow to America; in fifty years these birds became so numerous as to be more harmful than the tent-worm, and we should like very much to send them all flying back to where they came from! When before our very eyes the robins steal the makings of a cherry pie from the top of our cherry tree, we are very angry, but nobody dares to kill off the whole race of robins and sparrows because we should then be tormented and our trees and crops destroyed by the millions of insects upon which these birds feed. If by some dreadful accident all the birds in the world should die, in six or ten years all of our trees, our grasses and

flowers, our gardens and our crops would come to an end.

Every year man is learning more about Nature, with every generation he has more power over his surroundings, dares tamper further with the elements, with the living secrets of Nature, than did his fathers, but he must be careful! In his heart man feels that he can conquer Nature, he can train her hosts, her battalions of living things to be his willing slaves—but not yet! The time is not yet come; man and boy and girl—all of us—must first watch and study and know and respect the armies of Nature; *then* she will give them to us for our use!

CHAPTER XI

More About the Web of Life—The Soil

If I were to read a book, and I came to a chapter called "Soil," I think I should be tempted to skip it, because "Soil" seems such a dull subject. How, I might ask, can anyone find a story in the soil?

Fossil Fish

But there is a story in the soil. The soil, you know, is the topmost layer of the earth's surface, and it is made of rocks, all crumbled and shaken and beaten to bits by time and tempest, by snow and ice and sleet and the fierce heat of the sun. You yourself have seen rocks crumble and flake. Rain and frost, sudden changes from heat to cold, cause the rocks to swell and shrink again so that small pieces are chipped off. Rain seeps into the rocks and melts some of the material holding them together so that the surface falls away in a loose, powdery mass. This has been going on for years and years, for ages and

ages, so that these finely ground particles of rock form the main bulk of the soil covering the earth. If all the soil in your garden, if all the soil in America were swept into the sea, the bare rocks beneath would after long years become covered with soil by the weathering of the rocks beneath.

Dig through the soil and the sub-soil, and you will strike rock, as you know. But not all soil is of the same nature as the rocks beneath. The soil in your garden may have been carried there by the great ice sheets which swept the earth thousands of years ago. Some was laid by rivers long since dried, a rich dark soil which makes fertile the valleys in which it lies.

I cannot stop here to tell you the story of the earth. Mother Earth, so the books tell us, is fifty million years old, and in fifty million years she has had too many adventures to put into this little chapter or this little book. And all the time the sun looked on—what a story he could tell! Unwinking, the sun watched our earth, a whirling mass of flaming gas, cool and harden to hot rock, to cool rock, to sea! He saw mountains levelled, plains thrown up into hills; as he watched, the sea became land, and the land sea. That warm Mediterranean, on the shores of which the young Grecian priests heard their destiny in the whispering leaves of the sacred oak of Dodona—that warm sea was once a fertile valley,

bright with trees and grass and flowers. The sun saw the first life arise upon the earth, mosses, ferns, gigantic trees, sponges, and blind sea creatures. Then he saw worms and shell-fish, back-boned animals with wings and limbs, birds, reptiles, mammals that suckled their young, and lastly, Man.

Then he saw the great glaciers creep slowly south, and crawling inch by inch over the face of the earth, blast with their breath all these living things so that they died and, covered by the ice, were forgotten.

How do we know all this? We know it by the record of the rocks, wherein were imbedded the bones of these strange animals, and upon which lie the pictured outlines of many a leaf, many a shelled sea creature now unknown to man. We know it by the fossils, which are plants, tree trunks and even bones, turned to stone by time, and so preserved that we may therein read the history of the earth.

Time after time life arose upon the land, only to be crushed again by the relentless onward sweep of the glaciers. The very last changes of level took place after the melting of the last ice sheet. Continents were drained, deserts laid in shifting sand, the soil settled into its final form and content, and living things began to shape themselves and adapt themselves to life in their particular climates.

Here again we see another strong link in Nature's Web of Life. It was the plants which prepared the dry land for animals. The barren land of those ancient times afforded no food or shelter for animals; not until plants appeared could the creatures crawl out of the sea and carry on their great adventure of life upon the shore. And besides food and shelter and places to hide, the plants gave one more thing to the animals; perhaps you can guess what this was if you recall Chapter I, on "The Leaf." Can you remember that magic fluid in the leaf, called "chlorophyll?" And do you remember the tree-breathing, or *transpiration*, by which the tree breathes in carbon dioxide and breathes out oxygen? Of course you do, and you remember also that oxygen in the air is necessary to keep the fires of life burning in us and in all animals. So plants gave oxygen to the animals.

In the long run, then, all animals depend on plants, and all plants depend upon the soil.

The soil is not dead. Although it looks as lifeless as a stone, it is filled with living creatures, insects, earth-worms, and tiny creatures called "bacteria" which are busy all day long making the soil fertile that your gardens may grow. These bacteria are as small as our old friend the ameba, but they are hard workers. When in autumn the leaves fall from the trees, when the green plants die, they disappear, but they are not wasted.

They become part of the soil, they are buried and decay, and as they decay the bacteria change them into stuff called "nitrates" which enrich the soil.

Even the soil is full of Nature's magic!

When the farmer complains that his crops will not thrive because his soil needs *humus*, he means it has not enough of this decaying green matter, and his crops are starving for want of proper food. He has to go and buy some humus which has been prepared by men, or he must let his fields lie idle, without sowing seeds for a year or two, so that the bacteria may have a chance to work on the decaying green things ready at hand.

How does the farmer know when he has found good soil? He knows by the color, and by the weight; he makes sure also that his fields will have a chance to get plenty of water, because he realizes, as you do, that of all things, plants most need water. Water not only feeds the plant, but it helps dissolve the soil-food and to carry it through the soil and up the roots into the living stem or trunk. Too much water, of course, like too much of anything, is bad for plants. A flooded field will kill the farmer's wheat by closing up the pore-spaces or air-spaces in the soil; even roots must have air or they will suffocate. The flooded field, however, would not kill our oak, because our oak is strong enough to stand a great deal of hardship.

Does it not seem strange that in a shovelful of soil, nearly half of the total volume is pore-space, this air-space between the particles of earth?

The other day I watched the gardener plant some shrubs. First he dug his hole and put in a bush; then, when he had filled in the earth all round, he stamped it gently down with his foot. After he had watered it well he sprinkled loose earth over the firm soil; he told me this loose earth kept the water from evaporating into the air. He said that plants get their moisture from two sources, from the rain which falls from above, and from the ground water which rises from below—the water men find when they dig wells. It is a curious fact that when water finds tiny cracks or spaces in solid earth or rock, it is drawn upward to the soil where the roots of plants can drink it. The cracks must be very fine, though, finer than a hair, or the water will not follow them; that is why, the gardener said, that he scatters loose earth or straw over the trampled earth around his newly planted bushes. In this loose earth the cracks are too coarse to draw the water up where it will pass into the air, and so it remains in the soil where the plants need it.

And now it is time to speak of one more link in the Web of Life, a strong link and an important one, although it is made by creatures we look down upon as the lowliest of all living things. There is a humble crea-

ture, not pretty to look upon, but which does a great service for the living world.

This creature is the earthworm, and he makes the soil richer for plants, thereby helping man and beast. The earthworm lives in the soil, which he devours as he burrows through it. The earth passes through his body, and when it comes out it is richer than when it went in. He buries the dead leaves which, when they have been worked upon by the bacteria, make rich and ready food for the young plants of another spring. You and I know only one kind of earthworm, and he is never more than ten inches long, but there are more than a thousand kinds, each quite different from the other. In tropical countries people have seen worms from three to six feet long!

The first person to study earthworms was Charles Darwin, when he was a young student at Edinburgh, in Scotland. A very queer subject for a student to choose, was it not? Yet this young student became one of the greatest men of the world, and what he learned about earthworms has been of much use to mankind. Young Charles Darwin would measure off a space upon the ground, then he would count the number of wormholes in this space, and figure out how many leaves these worms took down into their burrows. He found that in an acre of fine old fallow ground there may be half a

million worms; they will eat almost anything they can get their skins over, so that in one acre of ground they pass ten tons of soil through their bodies every year. They have been doing this for millions of years; every bit of soil on the surface of the earth has passed through their bodies many times.

Darwin found that the worms work chiefly by night, when he would see hundreds of them, "with tails fixed in their burrows, prowling round in circles," and strongly resisting any effort to pull them out. "An age-long ploughing field which was so thickly covered with hard flints that it was known as 'the stony field' was left untouched for thirty years, after which a horse could gallop from one end to another without ever striking a stone."

All his life Darwin continued this patient study, and when he was seventy-two, the year before he died, he published a book which proves that earthworms have made most of the fertile soil of the world.

"When we behold a wide, turf-covered expanse," wrote Darwin—I have changed one or two of his words—"we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the unevenness having been slowly leveled by worms. How marvelous to know that the whole of the top soil over any such expanse has passed, and will soon pass, every few years

through the bodies of worms. The plough is one of the most ancient and most valuable of man's inventions; but long before he existed the land was regularly ploughed by earthworms. It may be doubted whether there are many animals which have played so important a part in the history of the world, as have these lowly creatures."

Without earthworms the soil would soon become cold and hard, unfit for plants to grow in.

Without bees the clover would die.

Without birds the trees and plants would die, eaten by the myriad insects ready, if unchecked by birds, to swarm from the earth in a dark destroying cloud.

Without plants the animals would starve—but this story could go on forever, like the story of "The House that Jack Built."

What have you seen that you can add to the story of Nature's Web of Life?

CHAPTER XII.

Wonders of Wood

Think of what we make out of wood!

We make—

Railroad ties.

Boxes.

Telegraph poles.

Crates.

Fences.

Excelsior for packing.

Fence posts.

Wood pulp for paper.

We cut fire-wood to burn; we make frame houses with shingled roofs and all that goes under the roof! Look around you—how many wooden objects can you count?

And the ships! Think of the Trojan galleys, centuries ago, their long oars flashing in the sun, the brown backs of the rowers glistening as they bent to their task. Think of the great Armada, that fleet of square-sailed Spanish gal-

Woodsmen

lows beaten so bravely by the English sailors of Queen Elizabeth—think of Columbus' ship! A stout vessel she was, planked with oak; her masts were of oak, too, I think, cut from trees a hundred years old. Nowadays we need longer masts, so we find them among the tall, straight pine that grows in Oregon and along the shores of the Great Lakes or in Canada and Northern Maine.

Suppose you were Captain Jack Tar, and you had built a great schooner to sail across the sea. There she lies in the ship-yard, ready, all but her masts. There must be three of them, each a hundred feet high. Captain Jack boards the train and he travels north, until one fine day he reaches the lumber camp. Brrrrr, but it is cold! Ten degrees below zero! The snow lies deep upon the ground, in the forest each tall pine wears a white and fluffy crown.

"Come along, Jack Tar!" cry the woodsmen, and out from camp they all go, axe and saw in hand.

"Ah!" says Jack, "Keep those three straightest pines for me!" And back he goes to sea, but the woodsmen's work is only just begun. They have been in camp since early autumn, but no one grumbled when the snow came, because that made the rough logging roads smoother for heavy sled loads. They have hewn the branches from Jack's masts now, and the three of them are ready to be hauled to the bank of a stream. But first the men troop back to camp for dinner; a good dinner it is, too, and they deserve it. Pierre, the big Canadian cook, is an important person in camp and knows that a man's job cannot be done without plenty of good hot dinners.

On Sundays the men can go in to the nearest town if they wish, but most of them stay in camp, resting and sleeping and telling yarns.

Weeks pass, and months. On the banks of the stream where lie Captain Jack's masts the water rises higher and higher as the ice breaks and the thaw begins. With cant hooks and peavies Jack's logs, and hundreds like them, are flushed into the rushing water, and the drive to the saw-mill begins.

And what a drive this is! For miles upon miles the great mass of timber rides easily upon the current, and the driver rides with them. Nimbly he leaps from log to log; pushing this log and turning that one, he guides

Woodsmen Driving Logs Down a Stream

them upon their course. What he dreads most of all is to see his logs *jam*; that happens when somewhere one log gets twisted and blocks the passage so that the whole

piles up in a booming, roaring mass which can be loosened only with dynamite. This means that Jack's masts will be shattered and lost and with them hundreds of other precious logs, so when the driver sees this coming he forgets the danger of rushing, icy water and trusts the sharp spikes in his heavy boots to steady him as he runs forward and with a thrust of his pole loosens the key log which causes the trouble.

On again moves the mass, on and on until, after a journey of many days—it might be weeks in Canada or the northwest—the driver shouts as he sees the saw-mill, and Jack's masts pass from the water to the saw to be rounded into shape. From the mill they travel by train to Jack, waiting by the sea. Up go the masts, up fly the sails, off glides the great ship!

Once I visited a saw mill. It was in Oregon, on the Pacific coast, and the logs which came into that mill were so big that if four of you joined hands, you could not have reached around one of them. In an airy room over the water screamed the whizzing saws, shining round wheels forged of steel no thicker than a silver dollar. Men did not spin them, but machinery; their sharp teeth sank through the wood as a knife goes through an apple.

Do you know how many different kinds of saws there are? Ninety kinds, each with its own name; jump saw, wobble saw, foxtail saw, rabbit saw,—but if you want

to know any more, you must hunt for them in the dictionary.

It is all very thrilling, this business of the river drive, but nowadays, I am afraid, men have thought out quicker and less romantic means to bring the timber to the saw mill. Only certain kinds of wood are light enough to float upon the stream, so men have built logging railroads, timber slides—which are toboggan slides for trees—and flumes and cable tramways. If you had been born in Canada at the beginning of this century and your father had been a woodsman, you might very likely have ridden on the logs yourself. In driving season your father would have taken you and your mother and brother and sister upon a raft made of big logs, on top of which he had built a shanty. There you would have lived and watched the tree-clad river banks slide by, while at noon-time the smoke curled from the tin chimney rising crookedly from the stove where your mother was cooking the dinner. In Germany, too, men drive such rafts down the Rhine river from the Black Forest to the Low countries at the river's mouth.

In our western forest land live men called "cruisers" or "landlookers." These men have grown up among the forests, they know the trees for hundreds of miles, and they can guide lumber dealers to the finest trees; in their pockets they carry little blank books containing

forest maps which they made themselves, and you may be sure they are proud of these maps and careful to whom they show them.

How would you like to be such a cruiser?

Of course, in different parts of the country lumbering is done in different ways. But wherever trees grow, men are busy cutting them down; they are in such a hurry they do not stop to carry away the branches, much less to bundle the twigs into fagots for fire-wood like the thrifty Frenchmen. Indeed, I am afraid the American woodsmen slash at our forests with little mercy, leaving behind them a dreary waste of blackened stumps where the birds will never come again.

The trouble is, we have not forgotten the feelings our forefathers had about the forests. To the pioneer the forest was an enemy; it hemmed him in on every side, for hundreds of miles it stood between him and the cities he had left behind. Before he could build his log cabin and plough his field he must make a clearing in the forest; what cared he if the felled trees rotted on the ground? The forests, he thought, were limitless, endless; he would not have believed if someone had told him that in a hundred years people would be wondering where they could find wood enough to build their homes.

A forest trail! Modern city folks have forgotten what that really means. Often it was not even a footpath, just a number of landmarks the traveler must look sharp to find,—a queerly shaped rock, a dead tree, a spring. Even to-day the natives of our northern forest lands are terrified at the thought of losing themselves in the woods. If a man is lost in the forest for more than three days they say he will go crazy. Of course, he will get well when he is found, but for a time he will have had a very dreadful sensation. Not cold, not hunger oppressed him so much as loneliness; about him on all sides stretched the trees in endless, gloomy ranks; not a friendly sound could his straining ears catch, only the call of strange birds and the rustle of the thicket as some startled beast leaped out and away.

No wonder our forefathers learned to wield an axe, no wonder each felled tree to them meant victory!

The Yankee axe is the finest in all the world. Its head is forged of sharpest steel, its handle of toughest hickory—a tree, by the way, which grows only in America. And if the Yankee axe takes first prize, so does the Yankee woodsman; the sons and grandsons of our hardy pioneers an axe as an Italian wields his stone-cutting tools, with strength and skill.

We are proud of these backwoods forefathers of ours. They were strong and brave and ambitious; noth-

ing daunted them, not cold, nor hunger, nor savages, not loneliness nor the stubbornness of untilled soil. Why, our greatest American was a backwoodsman! Who was he, and how did he look? His long arms could split rails with the best of them, yet he was wiser than men brought up in cities.

Who was he?

Abraham Lincoln!

The day of the pioneer is past, but in our forests the axe still rings, the trees crash shivering to earth, and in our snug homes we think of the woodsmen who felled the trees for our fine furniture, our polished floors, our panelled walls and shingled roofs.

CHAPTER XIII

Our Beautiful Forests

Those were splendid lives our pioneer forefathers led, and what made them dare so far and toil so hard was the knowledge that the land they cleared belonged to them, the fields they ploughed were their very own; in the New World people were so few and land so plentiful it could be had for the asking, it was *free*.

Because the land was free our fathers came to America. In England the forests were far from free; they were owned by the king, by rich lords who were often cruel to their peasant tenants. Do you remember that old oak tree in our first chapter, the one we said was a sapling when William the Norman conquered England? That tree must have seen deeds done which dried the very sap in his young limbs. He saw poor people oppressed, driven from their homes, maimed or blinded for no greater crime than the killing of a stag to make meat for hungry children. In those days, you understand, a forest meant more than trees, it was a big slice of country containing not only woodland, but pastures and villages. To his rich landlord every peasant paid his tax, money or perhaps a sheep or fowl. Although hundreds of fine deer and other game abounded in the forest, if the peasant took bow and arrow to

kill a deer he was punished more terribly than we punish our worst criminals, he was tortured or put to death. Because it was the king's pleasure to hunt in the forest he would not spare even one stag for the poor man's food. The peasant could not so much as gather brushwood for his fire, much less cut down a tree; he could let his cows graze on the land, but not sheep or geese or swine, and if his cows nibbled enough to deprive the king's beasts of food, the poor man's cattle were taken from him.

There were plenty of officers to enforce these cruel laws; there were foresters and gamekeepers, rangers, woodwards, regards and verderers. Every forty days the verderers held court; the peasants were tried and thrown into prison until the grand Court of Justice should meet, which it did every three years. It was a lucky poacher who escaped with two ears from before those cruel judges.

And then came Robin Hood, outlawed Earl of Huntingdon, to roam the forest with his brave band, righting the wrongs of the oppressed, robbing the rich to give to the poor. Do you remember the story of Will Scarlet, one of Robin's men, how he saved a poor widow's boy from the gallows, how in so doing he was caught himself by the Sheriff of Nottingham, and how Robin's men in turn saved Will?

All this was long ago, of course, nearly a thousand years before our time, but doesn't it make you glad to know you live in a free land? Our government owns thousands of miles of glorious forests, wooded mountains, hills and streams. These lands are kept untouched for the pleasure, not of rich lords, but of common people. There is Yellowstone National Park in Wyoming, Yosemite Park in California, the Grand Canyon of Arizona, and many others which I hope you may one day see. If you are an eastern boy or girl and have never seen the big trees of California, ask your teacher to show you a picture of that giant redwood which is so big around that an automobile can drive right through its trunk!

These parks are vast playgrounds where grownups and their children can carry tents and camp out and have all kinds of good times. Nobody is allowed to cut down a tree or kill a wild animal in these beautiful places.

But beside their beauty and the value of their lumber, forests are very useful things. All these leaves with their faces turned like so many umbrellas to the sun shade the soil so the heat cannot burn the richness out of it. The tree roots hold the soil in place, keeping it from shifting or sliding downhill, holding back flooded streams which would otherwise drown the farmed fields in the surrounding country. Rocky soil never brings

a rich harvest, and tree roots, by forcing their way through cracks in the rocks, break up the stone and make an easier job for the earthworms.

Forest earth is full of decaying leaves and stalks, and you already know that makes the very best soil. In the swampy southlands the mangrove tree even makes soil where before was only water. The mangrove seed begins to grow while it is still attached to the mother tree, by the time it falls to the water it is a young plant which can easily find foothold on some coral reef. There it grows and spreads and forms a swamp which soon attracts other living plants. Then appears the cocoanut tree, and that means there is enough soil under foot for man to live upon. Thousands of miles of sea waste have been turned to land by the work of this wonderful tree.

Forests act as windbreaks. If a grove of trees stands between your field and the north wind, your crops will not be broken to earth in the storm.

How clean and sweet is the air among pine trees! Once I spent the night on the edge of such a forest, sleeping upon sweet-smelling pine needles. The spring water we had in that mountain camp was the purest and clearest I ever drank, and so it always is with forest springs.

Knowing the beauty and usefulness of our forests, should we not do all we can to keep them? Yet we do just the opposite. Our lumber dealers cut down millions of trees every year, never bothering to plant new ones in their stead, so that our America is fast losing her beautiful mantle of trees,—those same trees our pioneer fathers called enemies, but which we now know as our best friends.

But beside the man with the axe, our forests have other and worse enemies. Fires destroy miles upon miles of trees every year; have you ever caught the keen scent of pine smoke? It carries on the wind for miles; a native of Wisconsin told me he smelt burning pine in his city home, miles from the forest.

There is a greedy army which night and day seeks to lay waste the forests—the army of insects. One thousand different kinds of insects live upon the oak trees of our country. Some eat the roots, some burrow into the trunk, others, called “leaf rollers” and “leaf runners” devour the leaves. There are back-boring beetles, flat-headed borers, and caterpillars by the million ready to pounce on the luscious green. One, a big shiny black and red fellow called the forest-tent caterpillar, does more harm to oak forests than all other kinds of caterpillars put together.

Trees get sick the same as people, and they show it, too. They change color, they look "spotty," they get a temperature. When a deer or a goat or rabbit nibbles the bark off a young tree, letting insects burrow inside the tender cambium, the tree gets wound fever; sometimes trees with thin bark even sunburn as you do when you go without a hat in summer. Think how uncomfortable the city trees must be when the pavement is laid close around their trunks; the hard cement chokes off the water, it flattens and twists the roots. Every time I see such a tree I want to fetch a pick-axe and break away the cruel pavement.

Trees have their troubles, and there are tree doctors to cure them. On my neighbor's lawn stands a beautiful chestnut tree, insects attacked it and rotted it until the trunk was almost hollow and the tree was ready to die. Then tree doctors came and cleaned out that hole and filled it with cement as neat as any dentist fills a tooth; they saved its life, and my neighbor's children can have their roasted chestnuts as before.

CHAPTER XIV

The Man with the Microscope

I

When we look at Charles Darwin's picture and imagine him bending that grave, kindly face over the microscope, we wonder whether he didn't have to take his great bushy beard by the end and tie it to one ear to get it out of the way! But beard or no beard, look into the microscope he did, and found wonders there greater than a crystal gazer ever saw. He looked at bugs and beetles, worms and flies, sea animals and land animals, plants, leaves and grasses. He learned the habits of creatures that creep and crawl and fly and run, and, as he watched, he put two and two together and discovered the Web of Life, the relation between all living things. He discovered how living things grow and adapt themselves to changes of climate, why the duck has webbed feet and the lizard has eyes on the top of his head, why man alone of all creatures walks on two legs instead of four.

Of course, Nature would not have told these secrets to Darwin had she not known him to be patient and kind and a lover of everything alive. He used to walk alone in the woods, watching the life about him; he went so quietly that once three young squirrels ran up his

Charles Darwin

back and legs while their mother barked in terror from a tree. He had a sharp eye for birds' nests and could find them when nobody else could, but he never de-

stroyed the eggs nor carried away more than one. He lived in a big house in the country with Mrs. Darwin and their nine children and Polly, his favorite dog. Polly was a little white fox terrier who loved her master dearly and always seemed to know when he was going on a journey. Then she would mope and whine and cry, and when her master came home again she would go almost wild with delight, panting, squeaking, rushing around the room, jumping on and off chairs until he would stoop down and press her face to his. Polly used to tremble and put on an air of misery when her master went by to show that her dinner was late and she was hungry. Then Mr. Darwin would throw her crackers to catch on her nose.

Even when he was a boy, Charles Darwin began to study nature. He used to collect beetles; finding a new beetle was to him like finding a gold nugget! He kept on with his beetle-hunting while he was in college.

"One day," wrote Darwin, "tearing off some old bark, I saw two rare beetles and seized one in each hand; then I saw a third and new kind, which I could not bear to lose, so I popped the one which I held in my right hand into my mouth. Alas! it spat forth some dreadfully bitter fluid, which burnt my tongue so I was forced to spit the beetle out, which was lost, as was the third one."

I would never have put that beetle in my mouth, no matter how much I wanted it—would you? But this boy was so eager about beetle-hunting, as he was about everything he undertook, that in after life he could remember posts, old trees and banks where he had made a good capture. He was a capital shot with a gun, and so fond of the sport that the first time he brought down a snipe his hands trembled so with excitement that he could hardly reload his gun. In his room at college he would ask his roommate to wave about a lighted candle; then he would fire at it with blank cartridges, and if his aim was correct the puff of wind would blow out the candle. Darwin was never caught at this trick, but one day a teacher remarked,

“What a queer thing it is, Mr. Darwin seems to spend hours in cracking a horsewhip in his room, for I often hear the crack when I pass under his window!”

When he was a school boy Charles Darwin had many friends. He says himself that he must have been a very simple fellow when he first went to school, and in his life history he tells how one of his school mates fooled him.

A boy named Garnett took him into a cake shop and bought cakes, but did not pay for them. As the boys walked out, Garnett put his hand to his hat and moved it in a certain way. When Darwin asked why the shop-

keeper had let them go without paying, Garnett replied that his uncle had left money to the town on condition that anyone who wore his hat and moved it in a certain way was to be given whatever he wished. The truth was that the boy's father was known at the shops and the shopkeepers trusted him to pay promptly. Garnett repeated this in another shop, and then sent Darwin into a third, lending him the old hat. Of course, when Darwin moved his hat and turned to go without paying, the shop-keeper ran after him and gave him a trouncing, while the mischievous Garnett stood by and laughed.

I could tell many more stories about Darwin's boyhood, how he could beat the other boys at swimming races, how dogs would come to him from their masters, how when walking along a wall in a day-dream he fell off, how his father said to him when he was sixteen,

"You care for nothing but shooting, dogs and rat-catching, and you will be a disgrace to yourself and all your family."

The most interesting of all is the story of his voyage around the world in the *Beagle*, a small sailing vessel which took five years to make the trip. Darwin was twenty-one when they set out and sometimes he used to get pretty homesick, but he collected stones and bones and beetles to his heart's content, and learned many facts which were useful to him in later life. He was studying the rocks then, and tells how when the ship reached

port he would hurry ashore and clamber over the mountains with his hammer to learn by the sound what kind of stones they were, and what part they had played in the record of the rocks.

As he grew older Darwin became an invalid; he suffered very much, but he did not let his suffering interfere with his work. He wrote books about the facts he learned from nature; never satisfied to be *told* that something was true, he had to experiment and find out for himself. All our natural acts had for him a meaning, he wanted to know why we blush when we are embarrassed, why we start when we are frightened. One day at the "Zoo" he put his face close to the thick plate glass in front of a puff adder, having first decided that he would not start back if the snake struck at him, but as soon as the blow was struck he forgot all about his intentions and jumped backwards a yard or two as quickly as possible; he knew then that sudden fear is stronger than a man's mind.

By the time Darwin's beard was grey he was known over half the world, and like all great men, he had his enemies as well as his friends. He died in 1882, and if you want to know what he learned from all his study you can read it from his own books when you go to High School, because although he was so learned, his

books are not full of long words but are simply written so that everyone can enjoy them.

II

When Charles Darwin the Englishman was no longer young, there was born in Massachusetts a little baby who when he grew up was to be known everywhere as the "plant wizard," because he could help Nature to create plants that she could not make alone.

This baby's name was Luther Burbank, and he had barely learned to smile before he began to show his love for flowers. If anyone gave him a flower he would lie

Luther Burbank

in his cradle holding it tenderly in his tiny fingers, never crushing or dropping it, but keeping it until it faded or died. One day his sister gave him a daisy, and after he

had held it earnestly for some time, the petals fell off. With his fat baby fingers he tried patiently to put each petal back in place. When old enough to toddle he chose flowers for pets instead of animals; he used to carry in his arms a lobster cactus in a pot. Now I, for one, never saw a lobster cactus, and it does not sound very pretty to me, not nearly as dainty as a primrose or a daffodil. Perhaps you know better, but at any rate little Luther Burbank loved his lobster cactus so much that when one day he fell and broke the pot and plant he grieved over it as another child would weep over a lost bird or dog. Perhaps it was the remembrance of this broken cactus that made him create, when he was a man, a wonderful cactus plant without any prickles, good food for man and beast.

Luther Burbank's boyhood was very different from Charles Darwin's. Darwin's parents had money enough to send him to the best schools and colleges, Burbank was poor and had to go to work when he was still a boy. He worked in a factory until he had scraped together a few dollars, enough to start market-gardening and seed-raising. One day he noticed a peculiar seed-ball on the green top of one of his potato plants.

"Fine!" thought he, "Here is a new kind of potato. I'll watch this seed-ball and make sure the seeds are planted safely."

Alas, a few days later the ball was gone! Burbank hunted high and low until he found it on the ground over by the fence where some dog had rolled it; he put the seeds in the ground, and from them came the famous Burbank potato, which I am sure you have eaten for your dinner like hundreds of other boys and girls.

Burbank worked so hard in his garden that one scorching July day he had a sunstroke. This made him very sick; he was twenty-one then, and said he to himself,

“I am going west to California where the air is mild and the breezes soft, and gardens grow more quickly than in Massachusetts.” So to California he went, but he did not find life easy. He took any odd job he could get; for a time he cleaned chicken coops on a chicken ranch, and he was paid so little he had to sleep at night in the chicken house. After awhile he found work in a factory, but he was still so poor he could only afford to sleep in a damp room over a steaming hot-house where his clothes were wet day and night. Of course he became very ill, so ill that he would have died had not a good woman—herself poor—saved his life by bringing him fresh milk every day from her cow. When he was well enough he worked again from job to job, but he had better luck now and was able to save a little money. With this money he bought a small plot of

ground and planted the first trees of a tree nursery which was to become famous all over the country.

So Burbank went on raising trees and selling them, and the more he sold the more he planted. This took more money than he was able to make, so that he was always in need of cash to widen his business. He was as honest as your own father, but he was such a modest, bashful young man that he could not persuade the banks to lend him money. One day when he was digging away in his garden, wondering how on earth he was going to pay next month's bills, he saw a team of horses coming down the road, driven by a neighboring farmer whom everybody knew to be a miserable old miser. Imagine Burbank's surprise when the team drew up beside him and the old farmer began.

"Young man, I notice you're always tending to business. Need a little extra cash once in a while?"

And what did that farmer do but lend Burbank two hundred dollars without so much as asking for a promise!

At last fortune smiled on Luther Burbank, and he began to succeed. When his tree nursery earned for him ten thousand dollars a year, he shocked all of his friends by selling it. He said he was tired of raising trees just to sell them and make money, he wanted to spend his time making *new* plants and new trees and

new flowers; he wanted to cross-breed and cross-fertilize and play tricks with pollen that he alone knew how to play.

We have already spoken of some of the wonderful plants and flowers created by Burbank. It is said of him that he has done more in a generation in creating new and useful plants than Nature, unaided, could have done in a million years—more, indeed, than Nature, unaided, would ever have accomplished. The flowers and fruits of California are less wonderful than the flowers and fruits which Mr. Burbank has caused to grow.

Charles Darwin and Luther Burbank were very different kinds of men. Perhaps we ought not to call Luther Burbank “the man with the microscope,” because he spent very little time with books and microscopes; his days were spent in the garden working with his hands, and he gave to the world actual fruits and flowers which we can see and taste and enjoy. Darwin was the student, he was the real “man with the microscope;” he too worked with his hands, but mostly with his brain,—and there was a very mighty brain behind that high forehead!

Different men work in different ways to understand Nature and to help living things. Darwin was one, Burbank another; then there was the monk Mendel who planted and thought all alone in his convent garden;

there were the Frenchmen Cuvier and Lamarck, the German brothers Muhler, Agassiz the Swiss who lived in Massachusetts, and many others whose stories I should like to tell. They were patient men, and brave, and kind; in them the spirit of adventure ran high; theirs was the courage of a Francis Drake, a Captain Kidd, only instead of slashing around the world with swords, they stayed at home and found high adventure there.

All honor to the Man with the Microscope who conquers, not ships nor men nor gold, but Nature!

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