Elliot George Scott

The Romance of Plant Life

George Elliot

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Elliot G.

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CHAPTER I THE ACTIVITY OF VEGETABLES

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WHEN we remember either the general appearance or the way in which a cabbage or a turnip appears to exist, it does not seem possible to call them active. It is difficult to imagine anything less lively than an ordinary vegetable. They seem to us the very model of dullness, stupidity, and slowness; they cannot move even from one field to the next; they are "fast rooted in the soil"; "they languidly adjust their vapid vegetable loves" like Tennyson's Oak.

In fact one usually speaks of vegetating when anybody is living a particularly dull, unexciting kind of life in one particular place.

And it even seems as if the books, which are supposed to give us the best information about the study of plants, and which are not very attractive little books, quite agree with the ordinary views of the subject.

For one finds in them that plants differ from animals in being "incapable of motion." This, of course, just means that an animal, or rather most animals, can walk, swim, or fly about, whilst plants have roots and do not move from one spot to another. But it is not true to say that plants cannot move, for most plants grow, which means that they move, and in some few cases, we find that plants behave very much in the same way as animals do when they are touched or excited in any way.

We shall have to speak about tendrils, roots, and insect-catching plants later on. But it is perhaps the Sensitive Plant which shows most distinctly that it can shrink back or shrink together when it is bruised or roughly handled.

It will be described in its place, but just to show that this plant can move of its own accord, it is only necessary to hold a lighted or burning match about an inch or so below the end of a long leaf. If one does this then all the little leaflets begin to fold up, and finally the main stalk droops; soon afterwards other leaves higher up the stalk begin to be affected in the same way, and fall limply down one after the other. It is supposed that this movement frightens a grazing animal, who will imagine there is something uncanny about the plant and leave it alone. There are many respects in which this reaction of the Sensitive Plant resembles that found in animals. It does not take place if the plant is chloroformed or treated with ether; the leaves also get "fatigued" if too often handled, and refuse to rise up again.

There are, however, only a very few plants in which an immediate, visible answer to a stimulus can be detected. But all plants are at work; they have periods of rest which correspond to our sleep, but during their ordinary working hours they never slacken off, but continue vigorously active.

The life of man is so short that it is difficult to realize all that is being done by the world of plants. It is necessary to get beyond our human ideas of time. That is most conveniently done by considering how our plant world would strike an inhabitant of the planet Neptune. Our theoretical Neptunian would be accustomed to a year of 60,127 days (164 of our years); we will suppose that three of our years are a Neptunian week, and that ten of our days are about three-quarters of a Neptunian hour, whilst two earth-hours would be a minute to him.

If such a being were to observe our earth, he would be astonished at the rapidity of our vegetable world. The buds would seem to him to swell visibly; in the course of an hour or two, the bare boughs of the trees would clothe themselves with the luxuriant greenery of midsummer. Hops would fly round and round their poles, climbing at the rate of a foot a minute. Bare places, such as the gravel heaps near a sandpit, or the bare railroad tracks at a siding, would be perhaps in one week entirely covered by rich grass and wild flowers. In six Neptunian months a forest of graceful larches would spring up to a height of seventy or eighty feet.

So that, if one thinks Neptunially, the activity of plants can be easily realized.

The truth is that we are so familiar with common annual events, such as the regular harvest every year, that we never seem to realize what it means. There are some 1,400,000,000 human beings on the earth to-day, and they entirely depend on the work done every year by cultivated and wild plants.

Even in one of the least agricultural of all civilized countries, such as Great Britain, the cultivation of plants is still the largest national industry. In 1897 we grew enough corn to give a ration of 1lb. per diem to every inhabitant for 68 days, and we manage to get a large amount from every acre (28 to 33 bushels per acre). In most other countries the relative importance of land and of agriculture generally is very much greater than it is in Britain.

Moreover, it seems at first sight as if all this harvest had been made out of nothing at all. Plants do take in a small amount of mineral matter from the earth, but these minerals form but a very little part of the bulk of a tree or any vegetable substance.

A piece of wood can be burnt up in a fire and very little indeed of it is left. A few ashes will indeed remain, which are the minerals taken in from the earth, but all the rest has vanished into the atmosphere. The water which was contained in the wood has become steam and is evaporated; the woody matter consisted chiefly of compounds of a chemical substance, carbon, which also becomes an invisible gas (carbonic acid gas) in a fire and goes back into the atmosphere.

When the piece of wood was formed in a growing tree, it is easy to see where the water came from: it was taken in by the roots. Just as flowers drink up the water in a vase, and wither if they do not receive enough, so all plants suck up water by their roots. The carbonic acid gas is taken into plants through their leaves and is worked up into sugar, starch, wood, and other matters inside the plant.

But there is another very interesting point about the way in which wood is burnt in a fire; heat and light are obtained from a wood fire. Where did that heat and light come from?

If you walk in summer, under a tree in full leaf, it is much cooler than it is in the sunshine outside. This shows what happens: the sunshine has been taken up or absorbed by the leaves of the tree. It does not pass through the foliage, but the heat and light are stopped by the leaves.

The light and heat which were used up by the leaves in making wood, sugar, and starch come back again when that wood or starch is burnt.

So that the burning up of a bit of wood is just the opposite to the formation of that wood in sunshine in a living tree. The important point is that it is the sunshine which is used by plants to make all these refractory bodies, such as water, carbonic acid gas, and others, unite together to form sugar, starch, and wood.

As the earth revolves upon its axis, sunlight falls successively on every acre of land. Almost everywhere it is intercepted by green foliage. Each leaf of every plant receives and absorbs as much as it can, and, for so long as the light lasts, its living particles are hard at work: water or sap is hurrying up the stem and streaming out of the leaves as water vapour. Carbonic acid gas also is hurrying into the leaves; inside these latter first sugar and then starch is being manufactured, so that the green cells become filled with starch or sugar.

So soon as the light fails, the work begins to slacken. When darkness sets in, the starch changes to sugar and passes down the leaf-stalk into the stem, where it is used up in growth, in the formation of new wood or in supplying the developing flowers or young buds.

Next morning when the sunlight touches the plant all its little living cells set to work again, and another day's task is begun. It is very difficult to understand what is going on inside the leaf. If you were to imagine a square yard of leaves all taking in sunshine and making starch as they do in fine weather; then if you weighed all these leaves, and then weighed them again one hour after they had been in the sunshine, of course that square yard of leaf surface should be heavier, because a certain amount of starch has been formed in it. The amount actually made in one hour has been estimated by Dr. Horace Brown as 1/500 lb. So that 100 square yards of leaves working in sunshine for five hours might make one pound of starch. But one can estimate the activity of plants in another way. Look at the amount of work done by the Grass, etc., on an acre of pasture land in one year. This might entirely support a cow and calf during the summer; all the work done by these animals, as well as all the work which can be done on the beef which they put on, is due to the activity of the grasses on that acre. Moreover it is not only these large animals that are supported, but every mouse, every bird, every insect, and every worm which lives on that piece of ground, derives all its energy from the activity of the plants thereon.

All work which we do with our brains or muscles involves the consumption of food which has been formed by plants under the warm rays of the sun.

So that man's thoughts and labour, as well as that of every living creature, is in the first instance rendered possible by sunshine.

But the sunlight, besides this all-important function, affects plants in other ways.

One of the most interesting of the early spring flowers is the Coltsfoot. On bare blackish and unsightly heaps of shale one may see quantities of its golden blossoms. Now if one looks at them on a fine sunny day, every single blossom will be widely opened and each will turn towards the sun.

In wet cold weather every blossom will hang its head and be tightly closed up. Exactly the same may be observed with the Dandelion, which is, indeed, still more sensitive than the Coltsfoot. In cold wet weather it is so tightly closed that it is barely possible to make out the yellow colour of the flower, but on warm sunny days it opens wide: every one of its florets drinks in as much as possible of the genial sunshine. Both opening and closing are produced by the warmth and light of the sun's rays.

It is also the same with Pansies. On a fine day they spread out widely, but in cold wet weather the heads hang over and the whole flower shrinks together.

Perhaps the most interesting of them all are the little Woodsorrel and the Crocus.

Both are exceedingly sensitive to sunlight, or rather to the cold. A mere cloud passing over the sun on a fine spring morning will close up the flowers of the Crocus. In cold weather, if you bring one of its flowers indoors and put it near a bright light it will open widely, sometimes in a few minutes.

What produces these changes? It is very difficult to say, but every change helps towards the general good of the plant. In warm sunny weather insects are flying about, and they can enter the flower if it is open. These insects help in setting the seed (as we shall see in another chapter). In cold wet weather the flowers are best closed, as the rain might injure the florets and because also no insects are abroad.

Both the Foxglove and the Blue Vetch (*Vicia Cracca*) are specially ingenious in their way of obtaining light. For the stalk of every separate blossom bends so that its head turns to the best lighted or sunniest side. Thus, if you have Foxgloves planted against a wall, every flower will turn away from it; if you plant them in a circular bed, every one turns to the outside, so that every flower can get the sunlight.

Every one who has kept plants in a window knows that the stems turn towards the light. This has the effect of placing the leaves where they can get as much sunshine as possible. The leaves themselves are also affected by sunlight. They seem to stretch out in such a way that they absorb as much of it as they can.

That, of course, is what they ought to do, for they want to obtain as much as possible of the sunlight to carry on the work of forming sugar and starch inside the leaf.

Not only each leaf by itself endeavours to place itself in the best light-position, but all the leaves on the same spray of, for instance, Elm, Lime, or Horsechestnut, arrange themselves so that they interfere with one another as little as possible.[1] Very little light is lost by escaping between the leaves, and very few of the leaves are overshaded by their neighbours on the same branch.

Thus all co-operate in sunlight-catching. But, when a number of different plants are competing together to catch the light on one square yard of ground, their leaves try to overreach and get beyond their neighbours.

On such a square yard of ground, it is just the competition amongst the plants, that makes it certain that every gleam of light is used by one or other of them.

Every one of all those plants of itself alters the slope of its leaves and turns its stems so as to get as much light as possible.

This light, as we have seen, is taken in by the plant. It is used to make the gas, carbonic acid,[2] unite with water: when these are made to join together, they form sugar; if the sugar is burnt the heat and light appear again.

By changing the amount and arrangement of the molecules in sugar, starch or vegetable fats, and many other substances can be formed. But it is the sunlight that makes all this possible.

Thus the sun not merely supplies the motive power for all animal and vegetable activity but, by its influence, flowers, leaves, and stems move and turn in such ways that they are in the most convenient position to intercept its light.

The sunlight, though all-important in the life of most plants, kills many kinds of bacteria and bacilli which love the darkness. The well-known radium rays are also destructive to bacteria, and hinder the growth of certain fungi (Becquerel's rays have a similar effect). The X-rays are not so well understood, but one can close the leaflets of the Sensitive Plant by means of them.

Carbonic acid gas forms but a small proportion of the atmosphere which surrounds a growing plant. Yet there is no lack of it, for when the leaf is at work forming sugar the particles of gas are rushing into the leaf, and other particles come from elsewhere to take their place. Every fire and every breath given off by an animal yields up carbonic acid, so that it is constantly in circulation.

This is more easily seen by tracing the probable history of an atom of carbon. We will suppose that it enters a grass leaf as carbonic acid gas and becomes starch: next evening it will become sugar and may pass from cell to cell up the stem to where the fruit or grain is ripening. It will be stored up as starch in the grain. This grass will become hay and in due course be eaten by a bullock. The starch is changed and may be stored up in the fat of the animal's body. When this is eaten at somebody's dinner, the fat will most probably be consumed or broken up; this breaking up may be compared to a fire, for heat is given off, and the heat in this case will keep up the body-temperature of the person. The carbon atom will again become carbonic acid gas, for it will take part of the oxygen breathed in, and be returned to the atmosphere as carbonic acid gas when the person is breathing.

Another atom of carbon might enter the leaves of a tree: it will be sent down as sugar into the trunk and perhaps stored up as vegetable fat for the winter. Next spring the vegetable fat becomes

[1] Kerner, *Natural History of Plants*; also Scott Elliot, *Nature Studies – Plant Life*.

[2] The gas Carbonic acid consists of one part of Carbon and two of Oxygen. It is invisible, just as are the gaseous states of many liquids and solids. Water-vapour is not visible, though water (liquid) and ice can of course be seen. Starch, sugar, cell wall substance, etc., all contain Carbon, Oxygen, and Hydrogen. Vegetable fat is not well understood, but starch helps to form it.

starch and then sugar: as sugar it will go to assist in forming woody material. It may remain as wood for a very long time, possibly 150 to 200 years: then the tree falls and its wood begins to decay.

The bark begins to break and split because beetles and woodlice and centipedes are burrowing between the bark and the wood. Soon a very minute spore of a fungus will somehow be carried inside the bark, very likely sticking to the legs of a beetle. This will germinate and begin to give out dissolving ferments which, with the aid of bacteria, attack the wood. Our carbon atom is probably absorbed into the fungus. Very soon the mushroom-like heads of this fungus begin to swell and elongate; they burst through the bark and form a clump of reddish-yellow Paddock-stools. A fly comes to the fungus and lays an egg in it. This egg becomes a fat, unpleasant little maggot which eats the fungus, and amongst others devours our carbon atom, which again becomes fat in its body. Then a tomtit or other small bird comes along and eats the maggot. That bird stays out too late one evening and is eaten by an owl. The owl, satisfied with a good meal, allows itself to be surprised and shot by a keeper. When its body is nailed to a door and decays away, the carbon atom again takes up oxygen and becomes carbonic acid gas, which escapes into the atmosphere, and is ready for a fresh series of adventures.

We must now consider the water which with carbonic acid gas makes up sugar, etc. All plants contain a large percentage of water. This may be as much as 95 to 98 per cent in water plants, and 50 to 70 per cent. in ordinary tissues; it is contained in every sort of vegetable substance.

But there is also a stream of water or sap which is almost always entering the roots, rising up the stem, and passing into the leaves. On these leaves there are hundreds of minute openings called stomata, by which the water escapes as water-vapour into the atmosphere. A single oak leaf may have 2,000,000 of these stomata.

It is this current of sap which keeps the leaf fresh and vigorous; it is also by this current that every living cell is supplied with water and kept in a strong, healthy condition.

The amount of water used in this way is very great; in four months an acre of cabbages will transpire or give out through its leaves 3,500,000 pints of water and an acre of hops from 5-1/2 to 7 millions. A single oak tree, supposed to have 700,000 leaves, must apparently have given off into the atmosphere during five months 230,000 lb. of water.

Sometimes the water is so abundant in the plant that it collects as drops on the tips of the leaves and falls off as fluid water. A very young greenhouse plant (*Caladium nymphaefolium*) was found by Molisch to give off 190 water-drops a minute, and in one night it exuded one-seventeenth of a pint.

The water is found stored up in the stems or leaves of plants, especially those of hot or dry climates. The Madagascar Traveller's Tree, *Ravenala*, has a considerable amount of water in a hollow at the base of its leaf, and it is possible to drink this water. The usual story is to the effect that a panting traveller finds this palm in the middle of the desert, and saves his life by quenching his thirst with its crystal-clear water. Unfortunately the tree never grows far from marshy ground or springs, and the water, which I tasted for curiosity, had an unpleasant vegetable taste, with reminiscences of bygone insect life.

These are, of course, exceptional cases; as a rule the tiny root-hairs search and explore the soil; the sap or ascending current passes up the stem and pours out into the atmosphere. There the vapour is hurried off by winds, and eventually condenses and, falling as snow or rain on the earth, again sinks down into the soil.

It is very difficult to understand how the sap or water rises in the trunks of tall trees; we know that along the path of the sap inside, the root-hairs and other cells in the root, the various cells in the stem, and finally those of the leaf, are all kept supplied and distended or swollen out with water. All these living cells seem to have the power of absorbing or sucking in water,[3] and eventually they are so full and distended within, that the internal pressure becomes almost incredible. Wieler found in the young wood of a Scotch fir that the pressure was sixteen atmospheres, or 240 lb. to the square inch.

[3] The ascent is assisted by the osmotic absorption of water at the root and by evaporation at the leaves.

Dixon, when experimenting with leaf-cells, found ten, twenty, or even thirty atmospheres (150 to 450 lb. to the square inch). No locomotive engine has cylinders strong enough to resist such internal pressures as these. It is an extraordinary fact, and one almost incredible, that the cells can stand such pressures.

Yet these minute living cells not only exist but work at this high tension, and, in some cases, they live to about fifty years.

In this favoured country of Great Britain, it is unusual to find any serious lack of water. But in Italy or Greece, every drop of it is valuable and carefully husbanded.

Sometimes in such arid dry countries, a small spring of water will form around itself a refreshing oasis of greenery surrounded everywhere by dreary thorn-scrub or monotonous sand. All the plants in such a spot have their own special work to do: the graceful trees which shade the spring, the green mosses on the stones, the fresh grass and bright flowers or waving reeds, are all associated in a common work. They protect and shelter each other; their dead leaves are used to form soil; their roots explore and break up the ground. It is true that they are competing with one another for water and for light, but they are all forming a mutual protection, and producing an annual harvest.

In a climate like our own we cannot, like the Greek, suppose a Nymph in the shape of a lovely young woman watching over the spring, for she would infallibly suffer from rheumatism and ague.

But every living cell in every plant in such an oasis depends upon the water of the spring. All the plants there form an association which can be quite well compared to a city or some other association of human beings. They do compete, for they struggle to do the most work for the good of the community, and they incidentally obtain their livelihood in the process.

Most plant societies or associations such as those which cover Great Britain are not so obviously dependent on one particular spring, but the plants composing them are associated in a very similar way.

CHAPTER II
ON SAVAGES, DOCTORS, AND PLANTS

Savages knew Botany – First lady doctors and botanical excursions – True drugs and horrible ornaments – Hydrophobia cure – Cloves – Mustard – Ivy – Roses and Teeth – How to keep hair on – How to know if a patient will recover – Curious properties of a mushroom – The Scythian lamb – Quinine: history and use – Safflower – Romance of ipecacuanha – Wars of the spice trade – Cinnamon, dogwood, and indigo – Romance of pepper – Babylonian and Egyptian botanists – Chinese discoveries – Theophrastus – Medieval times – The first illustrated book – Numbers of plants known – Discoveries of painters and poets.

IF we look back to the time when all men and women were mere savages, living like the Esquimaux or the Australians of to-day, then it is certain that every person was much interested in plants. Nothing was so interesting as daily food, because no one was ever certain of even one good meal in the day.

So that in those early times there was a very sound, well-grounded knowledge of roots, bulbs, and fruits. They knew all that were good to eat, all that could possibly be eaten in time of famine and starvation, and also every poisonous and unwholesome plant.

Some savage genius must have discovered that certain plants were "good medicine"; that certain tree-barks helped to check fever, and that others were worth trying when people had successfully devoured more than they could comfortably digest. The life of a savage meant tremendous meals, followed by days of starvation; even now, when young children are fed on rice in India, a thread is tied round their waist, and, when this bursts, they are not allowed to eat any more.

Very probably some of these early physicians were lady doctors usually of a certain age. Men were too busy with their hunting and warfare to have time to try experiments with drugs, to make concoctions of herbs all more or less disquieting and to find out if these were of any use.

So that such medicine-men or witches gradually came to understand enough about poisons or fruits to make themselves respected and even feared. They would, no doubt, make botanical excursions in the forest, accompanied by their pupils, in order to point out the poisonous and useful drugs.

It is worth noting, in passing, that this habit of botanical professors going on excursions with medical students has persisted down to our own times, probably without any break in the continuity.

But it was soon found advisable to make this knowledge secret and difficult to get. They did not really know so very much, and a mysterious, solemn manner and a quantity of horrible and unusual objects placed about the hut[4] would perhaps prevent some irate and impatient savage patient from throwing a spear at his wizard – or witch-doctor.

Shakespeare alludes to this in *Macbeth*. "Scale of Dragon; tooth of wolf; witches' mummy; maw and gulf of the ravin'd salt sea shark; root of hemlock digg'd i' the dark; … gall of goat and slips of yew"; and so on.

Most of their cures were faith-cures, and they were, no doubt, much more likely to be successful when the patient believed he was being treated with some dreadful stew of all sorts of wonderful and horrible materials.

This explains how it was that the knowledge of medicine became so mixed up with pure charlatanism and swindling that no man could tell which drugs were of real use and which were mere ornaments giving piquancy and flavour to the prescription. It is not possible to say that a snake's head,

[4] This is still the custom in the huts of the wizard or medicine-man in West Africa, where one finds small cushions stuck over with all sorts of poisonous plants, bits of human bones, and other loathsome accessories.

the brain of a toad, the gall of a crocodile, and the whiskers of a tiger, were all of them absolutely useless. Within the last few years it has been found that an antidote to snake-bite can be obtained from a decoction of part of the snake itself, and it has also been discovered that small quantities of virulent poisons are amongst our most valuable and powerful remedies.

Whether the savages and their successors the doctors of feudal times even down to the fifteenth and sixteenth centuries, suspected or believed that this was the case must remain a rather doubtful hypothesis, but there is no question "that the hair of the dog that bit him" theory of medicine was very prevalent.

The following was a cure for hydrophobia of a more elaborate nature: "I learned of a Friend who had tried it effectual to cure the Biting of a Mad Dog; take the Leaves and Roots of Cowslips, of the leaves of Box and Pennyroyal of each a like quantity; shred them small to put them into Hot Broth and let it be so taken Three Days Together and apply the herbs to the bitten place with Soap and Hog's suet melted together" (Parkinson).

This prescription is not so preposterous as it sounds. Box and Pennyroyal both contain essences which would be in all probability fatal to the germ of hydrophobia, and the soap and hog's suet would keep air from the wound.

Other prescriptions read like our modern patent medicines.

"Good Cloves comfort the Brain and the Virtue of Feeling, and help also against Indigestion and Ache of the Stomach" (Bartholomew).

"Senvey" (the old name of mustard) "healeth smiting of Serpents and overcometh venom of the Scorpions and abateth Toothache and cleanseth the Hair and letteth" (that is, prevents or tends to prevent) "the falling thereof. If it be drunk fasting, it makes the Intellect good."

Even in those days the people can scarcely have believed that drinking mustard improved the intellect. Many of the remedies and cures are obviously false, for example the following: -

"A man crowned with Ivy cannot get drunk."

"Powder of dry Roses comforteth wagging Teeth that be in point to fall."

The fact that the surgeon was also a barber, and also a "face-specialist," appears from the two following: —

"Leaves of Chestnut burnt to powder and tempered with Vinegar and laid to a man's Head plaisterwise maketh Hair increase and keepeth hair from falling."

Those whose hair turned grey could employ the following prescription: —

"Leaves of Mulberry sod in rainwater maketh black hair."

If a doctor was not quite sure of the endurance of a patient under these heroic remedies, he could easily find out if he would recover, for it was only necessary to try the following: —

"Celandine with the heart of a Mouldwarp" (that is mole, *Scottice* moudiewort) "laid under the Heade of one that is grievouslie Sicke, if he be in danger of Death, immediately he will cry out with a loud voice or sing; if not, he will weep."

In Lightfoot's *Flora Scotica*, there is an interesting account of the Fly Mushroom (*Agaricus muscarius*) which is not very rare in Britain, and which may be easily recognized by the bright red top or cap, with whitish scales scattered over it, and a sort of ring of loose white tissue round the stalk.

"It has an acrid and deleterious quality. The inhabitants of Kamschatka prepare a liquor from an infusion of this Agaric which taken in a small quantity exhilarates the spirits, but in a larger dose brings on a trembling of the nerves, intoxication, delirium and melancholy. Linnæus informs us that flies are killed or at least stupefied by an infusion of this fungus in milk and that the expressed juice of it anointed on bedsteads and other places effectually destroys" – what we may describe as certain lively and pertinacious insects with a great affection for man!

As a matter of fact the fungus is said to be a deadly poison.[5]

[5] Cooke, *British Fungi*.

These quotations are enough to show how the real medical knowledge of those times was encrusted with all sorts of faith-curing devices, sheer falsehoods, and superstitions. The most learned men of the Middle Ages were almost invariably monks and hermits, for there was nothing in the world of those strenuous times to attract a studious, sensitive disposition. The spirit of their learning can be judged from the wearisome disquisitions and lengthy volumes written about the Barnacle Goose and Scythian Lamb.

In certain deserts along the Volga River in Russia, a peculiar fern may be found. It might be described as resembling a gigantic Polypody; the stem is about as thick as a lamb's body and grows horizontally on the ground like that of the common fern mentioned; thick furry scales cover the outside of its stem, which ends at the tip in an elongated point. The blackish-green leaf-stalks springing from the furry stem end in large divided green leaves.

It occurred to some medieval humorist to cut off the upper part of the leaf-stalks, and to make a sort of toy lamb out of the four leaf-stalk stumps and part of the woolly or furry stem.

This was palmed off as a wonderful curiosity of nature, as "a plant that became an animal," upon the ingenuous tourist of the period.

Such a subject was thoroughly congenial to the learned mind in the Middle Ages, and an enormous quantity of literature was produced in consequence. The general theory is given in the following lines: —

"Cradled in snow and fanned by Arctic air,
Shines, gentle Barometz, thy golden hair,
Rooted in earth each cloven hoof descends,
And round and round her flexile neck she bends,
Crops the grey coralmoss and hoary thyme,
Or laps with rosy tongue the melting rime,
Eyes with mute tenderness her distant dam,
Or seems to bleat, a vegetable lamb."

Such is the old idea of a well-known fern, *Cibotium barometz*.

Yet the original researches of some African "Obi" wizard or red Indian were not forgotten, and gradually came into practice.

It must be remembered that these savages were true scientific experimentalists, and made discoveries which have been of infinite service to mankind. We remember great men like Harvey, Lister, and Pasteur, but we never think of the Indian who discovered quinine.

The quinine trees, the yellow variety or *Calisaya cinchona*, grow in the mountains of north-eastern Bolivia and south-eastern Peru, in wild, inaccessible places at heights of 5000 to 6000 feet. The Indians probably experimented with almost every part of every wild tree before they discovered the wonderful properties of this particular species. The quinine in nature is probably intended to prevent some fungus or small insect from attacking the bark: when quinine is used in malaria, it kills the fever germ which attacks the blood corpuscles of the sick person, so that it is of the utmost importance in all tropical countries.

When the Jesuit fathers reached Peru and made friends and converts of the Indians, they discovered this remedy. Soon after the Countess de Chinchon, wife of the Viceroy of Peru, fell seriously ill of fever and was cured by the use of Jesuit's bark or quinine. It was introduced into Europe about 1638, but for a very long time the entire supply came from South America. The British Indian government were paying some £12,000 every year for South American quinine and, at the same time, the supply was running short, for the Indians were cutting down every tree.

At last, in 1859 (on the suggestion of Dr. Royle in 1839), the adventurous journeys of Clements Markham, Spruce, and Robert Cross resulted in the introduction of the Cinchona now flourishing in

Madras, Bombay, and Ceylon. In 1897 British colonies produced about £43,415 worth of quinine, and the price is now only 7-1/2d. or 8d. a pound!

Such drugs as Safflower are of very ancient date. It was commonly employed in Egypt with other dyes and spices for embalming mummies. It is now used with carbonate of soda and citric acid to give a pink dye to silks and satins, and occasionally, in the form of rouge, to ladies' cheeks! How did the ancient Egyptians discover that this particular thistle-like plant (*Carthamus tinctorius*) had flowers from which a red dye could be extracted by a tedious process of soaking in water? The natural colour of the flowers is not red but yellow.

The history of other drugs reads like a romance. Ipecacuanha, for instance, was discovered by some unknown Indian who lived in the damp tropical forests of Brazil and New Granada. A worthy merchant in Paris obtained a little of the drug in the way of trade. Shortly afterwards he became very ill and was attended by a certain Dr. Helvetius, who was exceedingly attentive to him. The grateful merchant gave the kind-hearted physician some ipecacuanha. In the course of time the great King Louis XIV's son fell ill of dysentery, and Helvetius received 1000 louis d'or for his ipecacuanha.

A very interesting and romantic history might be written about the effect of drugs, dyes, and spices in developing trade. During the time when Britain was struggling to obtain a share of the foreign trade of Holland and France, such spices as Clove, Cinnamon, and Pepper were of the greatest importance. The Dutch, especially, adopted every possible method to keep the spice trade in their own hands. They cut down the clove, cinnamon, and other trees, in all the islands not directly under their control. They imposed the most barbarous penalties on any interloper. For instance, any one who sold a single stick of cinnamon in Ceylon was punished with death. When the English captured the island in 1796, all such restrictions were of course repealed. Nevertheless its cultivation remained a monopoly of the East India Company until 1832.

Logwood (*Haematoxylon campechianum*) is closely connected with the story of adventure and colonisation in the West Indies. Its use was at first forbidden by Queen Elizabeth as it did not yield fast colours; this was because the dyers of those times did not know of any mordant to fix them. Yet this is one of the few vegetable dyes which retain their position in the market in these days of aniline colours, and it is said to be a large constituent, with brandy, of cheap "port wine."

Indigo was known to the Romans, who imported it from India on camel-back by way of the Persian and Syrian desert. In the fifteenth century, when the Dutch began to introduce it in large quantities, it was found to interfere with the "woad"[6] (*Isatis tinctoria*) which was then a very important cultivated plant in Europe. In Nuremberg, an oath was administered once a year to all the manufacturers and dyers, by which they bound themselves not to use the "devil's dye," as they called Indigo. Its more recent history shows a very different system. In Assam and other parts of British India, enormous sums of money have been invested in indigo plantations. It has been estimated that four million pounds was invested, and that a population of something like 700 Europeans and 850 workmen to the square mile in Behar, were entirely supported by indigo plantations.

Now all these planters are ruined and the population is dispersed, because German indigo manufactured from coal-tar is destroying the sale of the British-grown material. The plant has pretty blue flowers and belongs to the *Leguminous* order. The dye is obtained by steeping the leaves and young branches in water, and it is finally turned out in blue powder or cakes.

Perhaps the most interesting of all these drugs is Pepper. The Dutch, in the days of Queen Elizabeth, had a monopoly of the East Indian trade, and they tried to cut down or burn all spice trees except those in their own control. They could thus form a corner in pepper, and alter the price as they felt inclined. At one period they doubled the price, raising it from three shillings to six shillings per pound. This annoyed the London merchants so much that they met together and formed the "Society

[6] The same "woad" which was used by the Britons to paint themselves with.

of Merchants and Adventurers trading to the East Indies." This was of course the original source of our great East Indian trade, and later on resulted in the Indian Empire.

At present, and for centuries past, the whole world is searched and explored for drugs and spices. Our medicinal rhubarb for instance, grows in China on the frontiers of Tibet; it is carried over the mountains of China to Kiaghta in Siberia, and from thence taken right across Russian Siberia to London and New York. It is closely allied to the common or garden rhubarb, which grows wild on the banks of the Volga.

It is only our duty to remember with gratitude all those long since departed botanists who have made our life so full of luxury and have supplied our doctors with all kinds of medicines.

The first doctors were of course just savage botanists, but as soon as men began to write down their experiences, we find botanical treatises. The first, and for a very long time the only, botanical books were intended to teach medical students the names and how to recognize useful flowers and drugs.

Medicinal herbs such as mandrake, garlic, and mint are found described on those clay cylinders which were used in Babylon instead of books, about 4000 B.C., that is some 6000 years ago! The Egyptians thought that "kindly, healing plants," such as opium, almonds, figs, castor-oil, dates, and olives, were derived from the "blood and tears of the gods"; that would be about 3000 B.C. It is not known how far back Chinese botany can be traced, but, by the twelfth century before Christ, some three hundred plants were known, including ginger, liquorice, rhubarb, and cinnamon.

Theophrastus, who flourished about 300 B.C., was a scientific botanist far ahead of his time. His notes about the mangroves in the Persian gulf are still of some importance. It is said that some two thousand botanical students attended his lectures.[7] It is doubtful if any professor of botany has ever since that time had so large a number of pupils. Dioscorides, who lived about 64 B.C., wrote a book which was copied by the Pliny (78 A.D.), who perished in the eruption of Vesuvius. The botany of the Middle Ages seems to have been mainly that of Theophrastus and Dioscorides. In the tenth century we find an Arab, Ibn Sina, whose name has been commemorated in the name of a plant, Avicennia, publishing the first illustrated text-book, for he gave coloured diagrams to his pupils.

After this there was exceedingly little discovery until comparatively recent times.

But Grew in 1682 and Malpighi in 1700 began to work with the microscope, and with the work of Linnæus in 1731 modern botany was well started and ready to develop.[8]

It is interesting to compare the numbers of plants known at various periods, so as to see how greatly our knowledge has been increased of recent years. Theophrastus (300 B.C.) knew about 500 plants. Pliny (78 A.D.) knew 1000 species by name. Linnæus in 1731 raised the number to 10,000. Saccardo in 1892 gives the number of plants then known as follows: —

Flowering Plants	105,231	species
Ferns	2819	"
Horsetails and Club-mosses	565	"
Mosses	4609	"
Liverworts	3041	"
Lichens	5600	"
Fungi	39,663	"
Seaweeds	12,178	"
	—	
	173,706[9]	

9. Saccardo, *Atti d. Congresso, Bot. Intern. di Genova*, 1892.

[7] Lascelles, *Pharm. Journ.*, 23 May, 1903.

[8] Bonnier, *Cours de Botanique*.

But, during the years that have elapsed since 1892, many new species have been described, so that we may estimate that at least 200,000 species are now known to mankind.

But it is in the inner meaning and general knowledge of the life of plants that modern botany has made the most extraordinary progress. It is true that we are still burdened with medieval terminology. There are such names as "galbulus," "amphisarca," and "inferior drupaceous pseudocarps," but these are probably disappearing.

The great ideas that plants are living beings, that every detail in their structure has a meaning in their life, and that all plants are more or less distant cousins descended from a common ancestor, have had extraordinary influence in overthrowing the unintelligent pedantry so prevalent until 1875.

Yet there were many, not always botanists, of much older date, who made great discoveries in the science. Leonardo da Vinci, the great painter, seems to have had quite a definite idea of the growth of trees, for he found out that the annual rings on a tree-stem are thin on the northern and thick on the southern side of the trunk. Dante[10] seems to have also understood the effect of sunlight in ripening the vine and producing the growth of plants (*Purgatorio*, xxv. 77). Goethe seems to have been almost the first to understand how leaves can be changed in appearance when they are intended to act in a different way. Petals, stamens, as well as some tendrils and spines, are all modified leaves. There is also a passage in Virgil, or perhaps more distinctly in Cato, which is held to show that the ancients knew that the group of plants, *Leguminosæ*, in some way improved the soil. I have also tried to show that Shelley had a more or less distinct idea of the "warning" or conspicuous colours (reds, purples, spotted, and speckled) which are characteristic of many poisonous plants (see p. 238).

But if we begin with the unlettered savage, one can trace the very slow and gradual growth of the science of plant-life persisting all through the Dark Ages, the Middle Ages, and recent times, until about fifty or sixty years ago, when a sudden great development began, which gives us, we hope, the promise of still more wonderful discoveries.

[10] "Guarda il calor del sol che si fa vinoGiunto all' umor che dalla vite cola."He is speaking of wine – that "lovable blood," as he describes it.

CHAPTER III
A TREE'S PERILOUS LIFE

Hemlock spruce and pine forests – Story of a pine seedling – Its struggles and dangers – The gardener's boot – Turpentine of pines – The giant sawfly – Bark beetles – Their effect on music – Storm and strength of trees – Tall trees and long seaweeds – Eucalyptus, big trees – Age of trees – Venerable sequoias, oaks, chestnuts, and olives – Baobab and Dragontree – Rabbits as woodcutters – Fire as protection – Sacred fires – Dug-out and birch-bark canoes – Lake dwellings – Grazing animals and forest destruction – First kind of cultivation – Old forests in England and Scotland – Game preserving.

"The murmuring pines and the hemlocks
Stand like harpers hoar with beards that rest on their bosom."
—*Longfellow.*

OF course the Hemlock here alluded to is not the "hemlock rank growing on the weedy bank," which the cow is adjured not to eat in Wordsworth's well-known lines. (If the animal had, however, obeyed the poet's wishes and eaten "mellow cowslips," it would probably have been seriously ill.) The "Hemlock" is the Hemlock spruce, a fine handsome tree which is common in the forests of Eastern North America.

These primeval forests of Pine and Fir and Spruce have always taken the fancy of poets. They are found covering craggy and almost inaccessible mountain valleys; even a tourist travelling by train cannot but be impressed by their sombre, gloomy monotony, by their obstinacy in growing on rocky precipices on the worst possible soil, in spite of storm and snow.

But to realize the romance of a Pine forest, it is necessary to tramp, as in Germany one sometimes has to do, for thirty miles through one unending black forest of Coniferous trees; there are no towns, scarcely a village or a forester's hut. The ground is covered with brown, dead needles, on which scarcely even green moss can manage to live.

Then one realizes the irritating monotony of the branches of Pines and Spruces, and their sombre, dark green foliage produces a morose depression of spirit.

The Conifers are, amongst trees, like those hard-set, gloomy, and determined Northern races whose life is one long, continuous strain of incessant endeavour to keep alive under the most difficult conditions.

From its very earliest infancy a young Pine has a very hard time. The Pine-cones remain on the tree for two years. The seeds inside are slowly maturing all this while, and the cone-scales are so welded or soldered together by resin and turpentine that no animal could possibly injure them. How thorough is the protection thus afforded to the young seeds, can only be understood if one takes a one-year-old unopened cone of the Scotch Fir and tries to get them out. It does not matter what is used; it may be a saw, a chisel, a hammer, or an axe: the little elastic, woody, turpentiny thing can only be split open with an infinite amount of trouble and a serious loss of calm.

When these two years have elapsed, the stalk of the cone grows so that the scales are separated, and the seeds become rapidly dry and are carried away by the wind.

These seeds are most beautiful and exquisitely fashioned.

The seed itself is small and flattened. It contains both resin and food material, and is enclosed in a tough leathery skin which is carried out beyond the seed into a long, very thin, papery wing, which has very nearly the exact shape of the screw or propeller of a steamer. This wing or screw is intended to give the seed as long a flight in the air as possible before it reaches the ground. If you watch them falling from the tree, or throw one up into the air and observe it attentively, you will see that it twirls or revolves round and round exactly like the screw of a steamship. It is difficult to explain what happens without rather advanced mathematics, but it is just the reverse of what happens in the steamer.

The machinery in the steamer turns the screw, and the pressure of the water, which is thrown off, forces the boat through the water; in the case of the pineseed, the pressure of the air on the flying wings makes the seed twirl or turn round and round, and so the seed must be a much longer time in falling. They often fly to about 80 or 100 yards away from the parent tree.

Once upon the ground, the seed has to germinate *if it can*; its root has to pierce the soil or find a way in between crevices of rocks or sharp-edged stones. All the time it is exposed to danger from birds, beasts, and insects, which are only kept off by its resin. But it is difficult to see, for its colour is just that of dead pine needles and its shape is such that it easily slips into crevices. Then the seven or eight small green seed leaves break out of the tough seed coat, and the seedling is now a small tree two inches high. It may have to grow up through grass or bramble, or through bracken, which last is perhaps still more dangerous and difficult. It will probably be placed in a wood or plantation where hundreds of thousands of its cousins are all competing together. "In this case, the struggle for life is intense: each tree seeking for sunlight tries to push its leader-shoots up above the general mass of foliage; but all are growing in height, whilst the lateral branches which are cramped by the neighbouring trees are continually thrown off. The highest branches alone get sufficient light to remain alive, but they cannot spread out freely. They are strictly limited to a definite area; the crown is small and crowded by those of the trees next to it, and the trunk is of extraordinary length."

The above quotation from Albert Fron's *Sylviculture* (Paris, 1903) refers to an artificial forest cultivated and watched over by man. But the trees in such forests have "extra" dangers and difficulties to fight against. Even scientific foresters admit that they are very ignorant of what they are trying to do. In fact, the more scientific they are, the more readily they will confess how little they really know.

Watch a labourer in a nursery transplanting young pine trees; each seedling tree has a long main root which is intended to grow as straight down into the ground as it possibly can. All the other roots branch off sideways, slanting downwards, and make a most perfect though complicated absorbing system. With his large hand the man grasps a tree and lifts it to a shallow groove which he has cut in the soil. Then his very large, heavy-nailed boot comes hard down on the tender root-system. The main root, which ought to point down, points sideways or upwards or in any direction, and the beautifully arranged absorbing system is entirely spoilt. The wretched seedling has to make a whole new system of roots, and in some trees never recovers.

All sorts of animals, insects, and funguses are ready to attack our young tree. Squirrels in play will nibble off its leading shoots. Cattle will rub against its bark, and the roedeer, a very beautiful creature, and yet a destructive little fiend from the tree's point of view, nibbles the young shoots and tears the bark with its horns.

A tree's life is full of peril and danger. Yet it is most wonderfully adapted to survive them. Take a knife and cut into the bark of a pine tree, and immediately a drop of resin collects and gathers on the wound. After a short time this will harden and entirely cover the scar. Why?

There are in the woods, especially in Canada and North Russia, hundreds of insects belonging to the most different kinds, which have the habit of laying their eggs in the wood of tree-trunks. In those regions the entire country is in the winter covered with snow and ice for many months. Insects must find it difficult to live, for the ground is frozen to a depth of many feet. Where are the eggs of these insects to be stored up so that they can last through the winter without injury?

There is one insect at least, or rather many, of which the Giant Sawfly may be taken as an example, which have ingeniously solved this problem. She painfully burrows into the trunk of a tree and deposits her eggs with a store of food at the end of the burrow. A drop of resin or turpentine, which would clog her jaws, makes this a difficult task, but, as we find in many other instances, it is not impossible, but only a difficulty to conquer. If it were not for the resin, trees might be much more frequently destroyed by Sawflies than they are.

The larvæ of the Sawfly is a long, fleshy maggot. Just at the end are the strong woodcutting jaws by which it devours the wood and eats its way out as soon as it feels the genial warmth of spring penetrating through the tree-bark. Many other insects hibernate or lay their eggs in tree-trunks. Some are caterpillars of moths, such as the well-known Goat moth; others are beetles, such as one which burrows between the bark and the wood of apple trees. The mother beetle lays a series of eggs on each side of her own track. Each egg produces a grub which eats its way sideways away from the track of the mother. The track made by these grubs gets gradually wider, because the maggots themselves grow larger and more fat with the distance that they have got from their birthplace. We shall find other instances of burrowing insects when we are dealing with rubber plants.

This resin or turpentine is a very interesting and peculiar substance, or rather series of substances. It is valuable because tar, pitch, rosin, and colophony are obtained by distilling it.

When travelling through the coast forests of pine trees in the Landes of Western France, one notices great bare gashes on the stems leading round and down the trunk to a small tin cup or spout. These trees are being tapped for resin, from which rosin is manufactured. It would be difficult to find any obvious connexion between music and the Giant Sawfly. Yet the rosin used by Paganini and Kubelik has probably been developed in Conifers to keep away sawflies and other enemies. This very district, the Landes in France, was once practically a desert, and famous as such in French history. The soil was so barren that no villages or cultivation were found over the whole length of it. Now that it is planted with trees which are able to yield firewood and rosin, it is comparatively rich and prosperous.

Storms are also very dangerous for tree-life. One can only realize the beauty of a tree by watching a pine or ash in a heavy gale of wind. The swing of the branches, the swaying of the trunk, the balancing support of the roots which, buttress-like, extend out into the soil, give some idea of the extraordinary balance, toughness, and strength in trees. Except in the case of the common umbrella, which is an inefficient instrument in high wind, engineers have never attempted the solution of the problem satisfactorily solved by trees. A factory chimney only 51 feet in height will have a diameter at the base of at least three feet. This means that the height is about seventeen times its diameter. But the Ryeplant, with a diameter at base of 3 millimetres, may be 1500 mm. high! That is, the height is five hundred times its diameter, and the Ryeplant has leaves and grain to support as well as its own stem! In Pine forests on exposed mountain sides there is almost always at least a murmuring sound, which in a storm rises into weird howls and shrieks. With Greek insight and imagination, the ancients supposed that spirits were imprisoned in these suffering, straining pines. That is most beautifully expressed in *The Tempest*, where the dainty spirit Ariel had been painfully confined in a pine tree for a dozen years, and "his groans did make wolves howl and penetrate the breasts of ever-angry bears."

One of the most interesting points in botany depends on the fact that evil conditions of any sort tend to bring about their own remedy. Endymion's spear was of "toughest ash grown on a windy site" (Keats). The prosaic chemical analyses of German botanists have, in fact, confirmed the theory there suggested, for it is found that the wood of trees grown in exposed windy places is really denser and tougher than that of others from sheltered woods.[11]

If one realizes all these dangers from insects, animals, and storms, the height to which some trees grow and the age to which they live become matters for astonishment and surprise.

The tallest trees in the world are probably certain Eucalyptus of Australia, which have obtained a height of 495 feet above the ground.

They are by no means the *longest* plants, for there are certain *rattans* or canes, climbing plants belonging to the Palm family, which may be 900 feet long, although their diameter is not more than

[11] Hartig finds the specific gravity of the wood in a tree is increased from 0-60 to 0.74 when the surrounding wood has been cut down. —*Bot. Central*, vol. xxx, p. 220.

two inches.[12] There are also certain Seaweeds in the Southern Ocean, off the coast of Chile, which attain a prodigious length of 600 feet (*Macrocystis pyriferus*, or "Kelp"). That is not so remarkable, for their weight is supported by other plants in the case of the rattans, and as regards the seaweeds, by the water in which they float.

The next in order to the Eucalyptus are those well-known Mammoth or Big trees of California (*Sequoia gigantea*). They grow only in certain valleys in the Sierra Nevada, at an altitude of 5000-8000 feet. Their height is usually given as from 250-400 feet, and the diameter sometimes exceeds thirty-five feet. Since they have become a centre of the tourist-industry in the United States, various methods have been adopted to make their size more easily realized. Thus a coach with four horses and covered by passengers is (or used to be) driven through a gateway made in one of them. The trunk of another has been cut off some feet from the ground, and a dancing-saloon has been made on the stump. It is at least doubtful if dancing would be very agreeable upon such a cross-grained sort of floor! A complete section of one of them was carried across the United States to make a dining-room table for an American millionaire. The age of one of these trees has been estimated at 3300 years. That is to say that it was a seedling in 1400 B.C., and has been peacefully growing in a Californian valley during all the time when Greece, Rome, Spain, France, Britain, and of course the United States, developed their civilizations. The specimen of the Mammoth tree in the Natural History Museum in London was 1335 years old.

The possible age of many of our common trees is much greater than any one would suppose. The "Jupiter" oak in the forest of Fontainebleau is supposed to be 700 years old. Another oak which was cut down at Bordya, in the Baltic provinces of Russia, was supposed to be about 1000 years old. Other millennial trees are or were another oak and two chestnuts: the oak grew in the Ardennes, the chestnuts still flourish, one at Sancerre (France), and the other the famous specimen on Mount Etna. There are also eight olive trees in the garden of Gethsemane at Jerusalem, which are certainly 1000 years old, and were, according to tradition, in existence in the time of Jesus Christ.

And yet all these trees are mere infants compared to Adanson's Baobab and the Dragon tree of Orotava. The celebrated traveller alluded to visited the Cape Verde islands in 1749 and found inscriptions made by English travellers on the trunk 300 years before his time. From the growth since then, he calculated that some of these trees were about 6000 years of age, and they were 27 feet in diameter.[13]

The record is held by the Dragon tree of Orotava, in the Canary Islands.

When the Spaniards landed in Teneriffe in 1402, its diameter was very nearly 42 feet. It was, however, greatly injured by a storm in 1827, and finally destroyed in 1851. (The wood was then made into walking-sticks and snuffboxes.) The age has been estimated at 10,000 years, or by other authorities at 8000 years only. The "dragon's blood" of the Canaries, a well-known remedy in the Middle Ages, was not, as is popularly supposed, derived from this tree, but was obtained from a totally different plant.

But there is a hazy tradition to the effect that the story of the Dragon which guarded the golden fruit in the island of the Hesperides was nothing but a garbled account of this redoubtable veteran of the plant world.

There is no particular advantage in growing to these enormous heights and clinging to life in this way for hundreds and thousands of years. Nature seems to have found this out and preferred the ordinary pines, oaks, and larches, which are mature in a few hundred years. In a thousand years, ten generations of larch or pine can be produced, and, as each is probably better than its predecessor, a distinct improvement in the type is possible. All these long-lived giants belong in fact to the less

[12] Bonnier, *Cours de Botanique*.

[13] Bonnier, *l. c.*

highly specialized orders of plants. They are like the primeval animals, the Mammoths, Atlantosauri, and Sabretoothed Tigers.

Yet when we come to think of the many and diverse perils to which trees are exposed, the existence of even these exceptional monsters seems very wonderful.

After a violent storm which had blown down many of the trees in a friend's park,[14] I visited the scene of destruction and discovered what had apparently in almost every instance produced it. Rabbits had overthrown these trees!

They had nibbled away part of the cork and part of the young wood on the projecting buttress-like roots at the base of the tree. In consequence, water, bacteria, and fungus spores had entered at the injured places, and part of the roots had become decayed and rotten. When the gale began to sway them backwards and forwards and a severe strain came on what should have been a sound anchoring or supporting buttress, the rotten part yielded, and these fine, beautiful trees fell a prey to the rabbit.

The influence of forests and timber on the daily life of mankind is a most romantic and interesting chapter in history.

Every savage tribe, every race of man, however degraded or backward, is acquainted with fire. Fuel is therefore a necessity of existence for all savages, and not merely for cooking. There is a very interesting passage in London's *The Call of the Wild*, when the Dog "Buck" in his dreams remembers a hairy man crouching over the fire with Buck's ancestor at his feet, whilst in the darkness all round them the firelight is reflected from eyes of wolves, bears, and even more terrible and dangerous brutes which have now happily vanished from the world. For protection at night fire was an absolute necessity. Even at that long-distant period, therefore, man had commenced to attack the forest. Unless one has had to tend a wood fire for twelve hours, it is difficult to realize what a quantity is required. To prepare fire was a long, laborious, and difficult operation; one piece of wood was placed on the ground and held in position by the toes, a pointed stick was taken between the two palms of the hand and twirled vigorously round and round until the heat was enough to ignite a piece of rotten wood placed as tinder.

Therefore smouldering branches were kept always burning, as they are to-day amongst the Fuegians and some other savages. It was a sacred duty to watch this fire, and the woman (usually old) who was entrusted with the task was very probably put to death if she failed. From this very ancient savage custom probably arose the cult of the Vestal Virgins in Ancient Rome.[15]

Another very important factor in savage life was the canoe or piroque necessary for fishing or to cross lakes and rivers. The first chantey of Rudyard Kipling has a probable theory, and is a beautiful account of how man first thought of using a floating log.[16] They hollowed out the log and "dug out" the canoe, by first lighting a fire on it and then scraping away the cinders; then the sides were pressed out, and it was trimmed and straightened to the right shape. All this was the idea of some paleolithic genius far more persevering and ingenious than any marine architect of our own days.

"Birchbark" canoes are not so common as Dug-outs. The tree, the White or Paper Birch, is found in Canada and the Northern United States; those Indians who discovered that the light, waterproof cork-bark could be fashioned into a canoe made a very great discovery, and indeed it was their canoes that made travel or exploration possible in North America.

When man began to long for a settled permanent home, it was absolutely necessary to find a way of living in safety. Wolves, bears, hyenas and other animals were abundant; neighbours of his own or other tribes were more ferocious and more dangerous than wild beasts. Some neolithic genius imagined an artificial island made of logs in the midst of a lake or inaccessible swamp. Such were

[14] Dunlop House, Kilmarnock.

[15] It will be remembered that they were obliged to keep the sacred fire always burning, and were put to death if they misbehaved. The fire was never allowed to go out during the whole of Roman history, and the custom has been even preserved in some Roman Catholic convents and chapels.

[16] *Seven Seas.*

the lake dwellings which persisted into historic times, and which are indeed still in existence in some parts of the earth.[17]

The trees were abundant; they could be felled by the help of fire and an axe, and the lake dwelling gave a secure defence. The wood of some of the piles supporting the great villages in Switzerland seems to be still sound, though it has been under water for many centuries. Some villages are said to have required hundreds of thousands of trees.

The forest afforded man almost everything that he used, bows and arrows, shelter, fuel, and even part of his food.

Nuts and fruits would be collected and when possible stored. In seasons of famine, they used even to eat the delicate inside portion of the bark of trees.

But as soon as the first half-civilized men began to keep cattle, sheep, and especially goats, more serious inroads still were made upon the forest. Where such animals are allowed to graze there is no chance for wood to grow (at any rate in a temperate country). The growing trees and the branches of older ones are nibbled away whilst they are young and tender. The days of the forest were nearly over when cultivation commenced. Dr. Henry describes the process of "nomadic" culture in China as follows: "They burn down areas of the forest; gather one or two crops of millet or upland rice from the rich forest soil; and then pass on to another district where they repeat the destruction."[18] A very similar process of agriculture existed until the eighteenth century in Scotland.

Thus the forest was being burnt or cleared for cultivation. It was devastated by black cattle, goats, and other animals, and it was regularly exploited for fuel and building every day by every family for centuries.

It is not, therefore, surprising that the ancient forests in Britain have disappeared. Dr. Henry mentions one square mile of virgin forest on the Clonbrock estate in Ireland. The *Silva Caledonica* of the Romans is said to exist in Scotland at the Blackwood of Rothiemurchus, at Achnacarry, and in a few other places. Of the original oak forest, which covered most of England and Southern Scotland, not a vestige (so far as is known to the writer) remains to-day.

There are in places very ancient forests. A few miles from Retford are considerable remains of Sherwood Forest, which is for ever associated with that genial bandit Robin Hood. One huge oak (called the Major) has or used to have a keeper always on guard and paid by Lord Manvers, but there are hundreds of aged oaks all round it. Then there is the Knightwood Oak and some other ancients in the New Forest.

But it is not certain that these even date so far back as the time of Canute, for so far as the New Forest is concerned, it seems that this was formed either by Canute or by William I. The Saxons seem to have destroyed most of the English forests.

In Scotland oak forest existed as far north as the Island of Lewis, in Caithness, Dornoch, Cromarty, and along Loch Ness, as well as in every county south of these.[19] The deer forests and grouse moors, now desolate, whaup-haunted muir-land and peat mosses, were flourishing woods of magnificent Scots fir at no very distant period. They ascended the hills on the Cairngorms to 1400 or 1500 feet, and in Yorkshire to 2400 feet.[20]

Even in remote historical times, such as those of Canute, the forests had become seriously and dangerously destroyed. This king was apparently the first to artificially protect the woods as a hunting preserve. He was followed by William the Conqueror and other sovereigns. The game preserves of the landed proprietors to-day are, of course, the remains of the same custom.

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[17] Munro, *Lake Dwellings*.

[18] *Royal Dublin Society*, vol. i. part v. No. 11.

[19] Niven, *Bot. Section British Association*, 1901.

[20] Boyd Watt, *Cairngorm Club Journal*, vol. iv. No. 20, January, 1903; Smith, Lewis, *Roy. Geog. Soc. Journal*.

Fortunately, however, we do not kill poachers or cut off their right hands, and we do not cut off the forepaws of poaching dogs, as used to be done in medieval days.

This connexion of forests with game no doubt prevented the entire disappearance of wood, but when, as is the case in England, the comfort of pheasants is thought of more importance than the scientific cultivation of forests, the result is often very unfortunate.

The use and value of timber is, however, too important a matter to take up at the end of a chapter.

CHAPTER IV
ON FORESTS

The forests of the Coal Age – Monkey-puzzle and ginkgo – Wood, its uses, colour, and smell – Lasting properties of wood – Jarrah and deodar – Teak – Uses of birch – Norwegian barques – Destruction of wood in America – Paper from wood pulp – Forest fires – Arid lands once fertile – Britain to be again covered by forests – Vanished country homes – Ashes at farmhouses – Yews in churchyards – History of Man versus Woods in Britain.

WHAT was the first tree like? That is a very difficult question to answer. Perhaps the first forests were those of the great coal period, of which the remains, buried for untold ages in the earth, became the coal which we now burn.

The flames and red-glowing heat of a fire are the work of the sunlight which fell in these long-past ages through a steamy, misty atmosphere, upon these weird, grotesque vegetables, unlike anything which now exists upon the earth. Their nearest allies amongst living plants are the little club-mosses which creep over the peat and through the heather in alpine districts.

Of course no one can say exactly what these coal forests were like. But although some modern authorities have questioned the general accuracy of the descriptions of Heer and others, yet, as they have not given anything better in the way of description, we shall endeavour to describe them according to our own beliefs, and as they probably existed in the Lanarkshire coalfield and other places in Britain.

In that gloomy mirk of the Carboniferous epoch, an observer (if there had been any) would have dimly perceived huge trunks rising to sixty or eighty feet and divided at the top into a very few branches. All branches were covered over by comparatively quite small leaves. Not a bad idea of the Sigillarias, Lepidodendrons, etc., which made the forest and can be obtained by carefully looking at a pan of Selaginella such as one finds in almost every botanical garden, and imagining this to be eighty feet high. Through the bottomless oozy slime which formed the ground, horizontal runners and roots penetrated in every direction. Great fern-like plants might be observed here and there. Sluggish rivers meandered slowly through these forests, carrying silt and refuse (their deposits are our Cannel coals). In the water and in pools, or perhaps in the mud, were curious waterferns with coiled-up crozier-like leaves. Perhaps horsetail-like plants of huge size might have formed great reed-beds to which those of to-day are as a plantation of one-year-old firs is to a pine forest that has lasted for a century.

Fishes and crustaceans, or lobster-like creatures, crawled and squattered through the slime, pursued by salamander-like animals with weak limbs and a long tail. Some of these latter were seven to eight feet long. Millipedes, scorpions, beetles and maybugs existed, and huge dragonflies preyed on them.

But there is one very ancient group of trees, the Araucarias or Monkey-puzzles, which are by no means uncommon even now. The ordinary one (*Araucaria imbricata*) is often planted in the British Isles, and it has, if you look closely at it, a most peculiar appearance. It is like the sort of tree that a child would draw; it is a clumsy attempt at one, and very different from the exquisite irregularity of the ash or oak.

Its leaves are especially curious: they cover the branches very closely, and are hard, rigid, and spiny. Its cones, though of the nature of pine-cones, are yet quite unique. The seeds are edible, and used to be an important article of diet to the Indians on the slopes of the Chilian Andes, where monkey-puzzle forests used to exist. This of course is a very out-of-the-way region; other species of Araucaria are found scattered about the world in a most perplexing manner. One kind grows in

Norfolk Island, in the Pacific; another occurs in the inner mountainous districts of Brazil; there are some in Australia and others in New Caledonia.

But in the Jurassic period of geology, in the age of ammonites and gigantic lizards and crocodiles, Araucarias were the regular, ordinary trees. They grew all over Europe, and apparently as far north as Greenland, and, indeed, seem to have existed everywhere.

Perhaps the spiny leaves discouraged some huge lizard, perhaps Atlantosaurus himself (he was thirty feet high and one hundred feet long), from browsing on its branches. Perhaps the Pterodactyls, those extraordinary bird or bat-like lizards, used to feed upon the seeds of the monkey-puzzle, and carried them in their toothed jaws to New Caledonia, Australia, and Norfolk Island. Other improved types have driven the monkey-puzzles from Europe, Asia, and Africa, and taken their places, but in out-of-the-way districts of South America and Australia they are still able to hold their own.

An ally of theirs, the Ginkgo or Maidenhair tree, seems to have been extremely common in certain geological periods. To-day it has almost entirely disappeared. A few trees were discovered in certain Chinese temples, where they had been preserved as curiosities for centuries, but it is almost extinct as a wild plant. The Bigtree group (*Sequoia* p. 47) was a companion of the Ginkgo in its flourishing period. So also were the Sago palms or Cycads. All the ordinary trees, Pines, Oaks, Beeches, and the like, did not appear upon the earth's surface till a much later period.

The most important economic product of trees is the timber which they furnish. Wood, as we have tried to show in the last chapter, has been always of the greatest importance to mankind. It is easily worked, durable, buoyant, and light, and it is used for all sorts of purposes.

Silver fir,[21] which is accustomed, when growing, to be continually swayed and balanced by the wind, is preferred for the sounding-board of pianos and for the flat part of violins, whilst Sycamore or hard Maple is employed for the back and sides of the latter.

But there are enormous differences in different kinds of woods. The colour of wood varies from white (Beech), yellow (Satinwood), lemon-yellow and bluish red (sap and heartwood of Barberry), to dark and light brown mottled (Olive), black (Persimmon), and dark brown (Walnut). Some woods have a distinct smell or perfume. Cedarwood, Sandalwood, Deal, and Teak, are all distinctly fragrant. The Stinkwood of South Africa and the Til of Madeira have an unpleasant smell.

More important in practice are the differences in the hardness and weight of wood. The Ironwood of India cannot be worked, as its hardness blunts every tool. It requires a pressure of something like 16,000 lb. to force a square-inch punch to a depth of one-twentieth of an inch in *Lignum vitæ*. Even Hickory and Oak (if of good quality) require a pressure of 3200 lb. to the square inch to do this. On the other hand the Cotton tree of India (*Bombax malabaricum*) has exceedingly soft wood. It is quite easy to drive a pin into the wood with the fingers.

Some woods are far too heavy to float: many tropical woods are especially very weighty. Perhaps the Black Ironwood, of which a cubic foot weighs 85 lb., is the heaviest of all. But the same volume of Poplar, Willow, or Spruce does not weigh more than 24 lb.

There are many ancient and modern instances of the extraordinary way in which timber lasts when at all carefully looked after. Thus the Cedar which "Hiram rafted down" to make the temple of Solomon (probably Cedar of Lebanon) seems to have been extraordinarily durable. Pliny says that the beams of the temple of Apollo at Utica were sound 1200 years after they were erected.

Cypress wood (*Cupressus sempervirens*) was often used to make chests for clothes because the clothes moth cannot penetrate it, and it also lasts a very long time. There is a chest of this wood in the South Kensington Museum which is 600-700 years old. The Cypresswood gates of Constantinople were eleven centuries old when they were destroyed by the Turks in 1453. The fleet of Alexander the Great, and the bridge over the Euphrates built by Semiramis, were made of Cypress. This wood

[21] The Romans used it for ships' masts and spars.

seems to have been of extraordinary value to the ancients, and was used for mummy cases in Egypt, for coffins by the Popes, as well as for harps and organ pipes.[22]

Perhaps the most valuable woods are Box, which is used for woodcuts, and Walnut, which used to be highly prized for gun-stocks, as much as £600 having been paid for a single tree.

But the most interesting histories of trade in timber belong to the commoner and more usual woods. The great woods of Jarrah (*Eucalyptus marginata*) cover 14,000 square miles of Australia, but they are being rapidly cut down and sawn up into small blocks to be carried right across the world in order to form the pavement which London cabmen and cab-horses prefer to any other.

One remembers also the beautiful Deodar forests of Afghanistan, and the Himalayas. Logs of deodar were floated down the rivers to form bridges or temple pillars in Srinagar, the capital of far Cashmere. Nowadays great "slides" are made, winding down into the valleys from the recesses of the hills. When winter approaches, water is sprinkled on the logs which make the slide; this freezes and forms a slippery descending surface, down which the deodar timber rushes till it reaches the low ground, where it is cut up into railway sleepers and takes part in the civilizing of India.

The fragrant Teak has an oleoresin which prevents the destructive white ants from attacking it; it is the most valuable timber for shipbuilding, and grows in many places of India, Malaysia, Java, and Sumatra. It floats down the rivers of Burmah, coming from the most remote hill jungles, and elephants are commonly used at the ports to gather the trunks from the water and pile them ready for shipment.

The Birch is carried all the way from Russia to Assam and Ceylon, in order to make the chests in which tea is sent to England and Russia (native Indian woods are also used). It is also used in the distillation of Scotch whisky, for smoking herrings and hams, for clogs, baskets, tanning, dyeing, cordage, and even for making bread.

But one of the most curious and interesting sights in any seaport is sure to be an old white Norwegian or Swedish sailing barque or brigantine. She will have a battered, storm-beaten appearance, and is yet obviously a comfortable home. The windows of the deck-house may be picked out with a lurid green. The tall, slowmoving, white-bearded skipper and his wife, children, and crew, not to speak of a dog and cats, have their home on this veteran "windjammer." She carries them from some unpronounceable, never-heard-of port in Norway, all over the world. You may see her discharging a cargo of deal plank, through the clumsy square holes in her stern, in a forgotten Fifeshire village, in Madagascar, in China, or in the Straits of Magellan. All her life she is engaged in this work, and her life is an exceedingly long one, to judge from the Viking lines on which she is built.

Moreover, her work is done so economically that it used to be much cheaper to use her cargo in Capetown than to utilize the beautiful forests of the Knysna and King Williamstown.

But there are not wanting signs that the forests of Norway, of Sweden, and even those of the United States, are doomed.

It is said that seven acres of primeval forest are cut down to supply the wood which is used up in making the paper required for one day's issue of a certain New York journal. What a responsibility and a source of legitimate pride this must be to the journalists! Let us hope that the end justifies the means.

Boulger calculates that in 1884 all the available timber from 4,131,520 acres of Californian Redwood was used in making the sleepers of the railways then existing in the United States.

He finds that no less than 18,000,000 acres of forest are necessary to keep up the supply of sleepers for the old lines and to build new ones.

So that, if we remember the wood required for paper, firewood, and the thousand other important requisites of civilized man, the United States must soon exhaust her supply and import wood.

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[22] Most of these interesting details are found in Boulger's valuable treatise on "Wood."

Then will come the opportunity of British North America. The Southern forest of Canada, which extended for 2000 miles from the Atlantic to the head of the St. Lawrence, has indeed gone or is disappearing into pulpwood and timber, but there is still the great Northern forest from the Straits of Belleisle to Alaska (4000 miles long and 700 miles broad), and in addition the beautiful forests of Douglas Spruce and other trees in British Columbia covering 285,000 square miles.

It is the wood-pulp industry which is at present destroying the Canadian forests. The penny and halfpenny papers, and indeed most books nowadays, are made of paper produced by disintegrating wood: it is cheap, and can be produced in huge quantities; nevertheless it is disquieting to reflect that probably nineteen-twentieths of the literary output of the twentieth century will be dust and ashes just about the same time (some fifty years) that the writers who produced it reach the same state.[23]

Yet, considering the amount daily produced to-day, the future readers of fifty years hence who are now in their cradles, may consider this a merciful dispensation of Providence.

One very curious use of wood may be mentioned here. Near Assouan, on the First Cataract of the Nile, one discovers broken granite or syenite needles, which had been intended by the ancient Egyptians for monuments. Where the broken pillar lies, there are rows of wedge-shaped holes cut in the rock.

They used to drive in wedges of dry wood and then wet them with water. The expansion of the wood split the rock, though this is hard granite or syenite. Very often the process failed because the stone cracked. The same method is said to be still used in some quarries.

The destruction of the forest is really necessary. Most of the corn land and rich pasture of the world has been at one time forest. It could scarcely be such fertile soil if it had not been for the many years during which leaf-mould fell on it, and the roots broke up and penetrated the subsoil below. Canada, Russia, and the United States are now passing through the same experience as that of Great Britain in the time of the Romans, Saxons, and Danes.

But there is terrible waste by fire.

When the trees become dry and withered in the height of summer in either India or the United States, some careless tramp may throw aside a lighted match. If a fire once starts, it spreads with enormous rapidity; great clouds of smoke roll over the surrounding country, and every village sounds the alarm. Everybody rushes to help and try to stop the conflagration, or if too late hurriedly saves whatever he can get of his possessions. His log hut and all the accumulations of years of saving may be turned into a heap of ashes in a very few minutes.

But the crackling of the leaves and the flaming twigs and scorching bark make such a volume of fire that nothing which man can do is of any avail.

Of course every beast, every bird and insect is in the greatest possible danger.

This is how a fire in New Zealand has been described by Mr. William Satchell: —[24]

"For a while it seemed that the battle must go to the wind, the fiery monster withdrew, lay hidden, roaring angrily in the dry heart of the woods; then insidiously he stretched forth his glittering arms, first one, then another, and locking the shuddering trees in an irresistible embrace, sprang once again erect. In an instant the whole bush from edge to edge became a seething, rocking mass of flames.

"'Fire! Fire!'

"Then, insignificant no longer, transfigured rather beyond all living possibilities of loveliness, the bush stood revealed to its centre. It became less a fire than an incandescence, waxing in brilliance to the point when, as it seemed, it must perforce burst into indistinguishable flame. Every leaf and twig of that fairy forest was wrought and hammered in virgin gold, every branch and trunk was a carved miracle of burnished copper. And from the golden leaves to the golden floor, floatingly or swiftly, there fell an unceasing rain of crimson flame petals, gorgeous flame fruits. Depth after depth

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[23] Compare the report by the Society of Arts.

[24] *The Toll of the Bush.*

stood revealed, each transcending the last in loveliness. And as the eye sought to penetrate those magic interiors there seemed to open out yet farther vistas, beyond belief beautiful, as of the streets of a city incorruptible, walled and towered, lost in the light of a golden incomparable star."

"'Fire! Fire!'

"In the face of that vision of glory the cry rang out with all the ineptitude and inappropriateness of the human weakling. On one side the titanic forces of nature, inexorable, eternal; on the other the man, frail of body, the creature of an hour, matching himself against them.

"'Fire! Fire!'

"Sheltering his face from the insufferable heat, the Swede hammered madly at the solid house-door. At the back, now utterly unapproachable, the kitchen, the roof, and a part of the main wall were already in flames. A few minutes – five at the most – would complete the demolition of the house. To right and left the great trees one after another went off like rockets, the roar of their burning foliage shaking the very earth. A deafening crashing of falling timber came at intervals from the bush beyond."

In some countries the destruction of the forests has had a very serious effect on the climate. The rain which falls upon a forest is partly absorbed by the leaves, and but a very small part of it is carried off by burns and streams: most sinks down into the forest soil, and is only gradually given back again after being taken in by the tree roots and evaporated by the leaves.

But bare hills denuded of wood allow most of their rain to rush down to the sea in dangerous spates of the rivers and burns, and then the ground becomes afterwards very dry and burnt up. There are very many countries now barren and desolate because they have been robbed of the beautiful forests which once covered the springheads and mountain valleys.

Perhaps Palestine is one of the worst instances. But it is when we remember Babylon, Nineveh, and all the cities of the coast of Asia Minor, as they were even a thousand years ago, and compare their present barren, desolate condition, that the full meaning of mountain forests becomes clear.

Where once there were thriving, prosperous cities with enormous populations, now the goats graze or a few miserable peasants carefully husband the water of a few miserable streams. The same thing has happened in Mauritius, in the Cape Verde and Canary Islands, and in many other places.

But men are now beginning to see how dangerous the destruction of forests may be, and in many countries and especially in Britain, new forests are being planted. Perhaps in time we may grow in Britain so much timber that we shall gain something like £32,000,000 a year, which is what we spend on imported woods.

At present plover, whaups, snipe, and grouse, or useless red deer, inhabit what was once the Caledonian forest, and every thousand acres of such land nowadays supports perhaps one shepherd and half a gamekeeper. But when it is planted again with woodlands it will afford a living to at least ten foresters, and surely a whole gamekeeper as well.

In the lowlands of Scotland and in England one often discovers, in walking over the hills, remains of cottages and farmhouses which have now vanished. The people have gone into the towns, and the healthy yeomen and farmers' boys have become weak-chested factory hands and hooligans. Such sites of old farms can often be recognized by a patch of nettles, and especially by eight or nine ash trees. These were always planted near the houses to give a ready supply of wood for spears. The ash, "for nothing ill," as Spenser puts it, would be available also for repairing the handles of tools, carts, etc. Some authorities say that it was the law of Scotland that these eight or nine ash trees should be planted at every "farmtoon."

So also, when forests began to vanish in England, laws were made to the effect that yew trees should be planted in every village churchyard. Probably this was to ensure a good supply of bows for the English archers, who, like the Scottish spears, were the best soldiers of their kind in Europe.

So that if we try to compare the conditions of man and of the forests in Great Britain from the earliest days, it would be something like this: —

1. When the earliest inhabitants lived on shell-fish, seabirds' eggs, nuts, and fruits, almost the whole country was covered by oak, Scotch fir, or birch forests.

2. When man was a hunter of reindeer and other deer, horses, cattle, and birds, he used much wood for fires and for building his lake dwellings.

3. When man kept herds of swine to eat acorns, black cattle, goats, and ponies, there would be many clearings and a great deal of open wood in which the cattle roamed about.

4. When man grew corn and other plants, the forest vanished altogether. Dr. Johnson said he scarcely saw a tree between Carlisle and Edinburgh. Yet first the King, then the Barons, had their parks and woodlands for preserving game. Moreover, the yews in the churchyards of England, and the ash trees by the Scotch farmtoons and peel-towers, were carefully looked after.

5. When great towns arose, and men became factory hands and steel workers, rich men began to make plantations in the lowlands, and to use the depopulated highlands for grouse moors and deer forests.

6. When men become wiser than they are now, it will be seen that great forests are necessary on all waste-land and barren places, both to keep a healthy country population and because it will pay.

CHAPTER V
FLOWERS

Man's ideas of the use of flowers – Sprengel's great discovery – Insects, not man, consulted – Pollen carried to set seed – Flowers and insects of the Whinstone Age – Coal Age flowers – Monkey-puzzle times – Chalk flowers – Wind-blown pollen – Extravagant expenditure of pollen in them – Flower of the pine – Exploding flowers – Brilliant alpines – Intense life in flowers – Colour contrasts – Lost bees – Evening flowers – Humming birds and sunbirds – Kangaroo – Floral clocks – Ages of flowers – How to get flowers all the year round – Ingenious contrivances – Yucca and fig – Horrible-smelling flowers – Artistic tastes of birds, insects, and man.

FOR many centuries flowers were considered as pleasing and attractive decorations stuck about the world in the same way as they are put in a drawing-room in order to give people pleasure. Very soon they were found to be extremely useful in poetry, sometimes to point a moral or disguise a sermon, like the primrose in *Peter Bell*, but more generally to produce a good impression on the BELOVED OBJECT. Burns puts the usual view of flowers very nicely in the following: "But I will down yon river rove amang the woods sae green, and a' to pu' a posie to my ain dear May." Possibly this is the meaning also in the exquisite lines of Shakespeare about the pansy: —

"Yet marked I where the bolt of Cupid fell:
It fell upon a little western flower, —
Before milk-white, now purple with love's wound, —
And maidens call it, love-in-idleness."

Even if there is no particular meaning, the "little western flower" gives point and beauty to the lines.

People only began to understand flowers about the year 1793, when Christian Conrad Sprengel, Rector of Spandau, near Berlin, published a very interesting work. He had discovered that the beauty of flowers and their colour and shape were by no means intended solely to please *human* eyes, but that they were designed to attract and allure the eyes of *insects*. Before his time there had been many guesses. Indeed, Theophrastus (born 371 B.C., and often mentioned in this work) seems to have quite well understood why flowers produce pollen, and that the fruit would not set and form seed unless pollen was carried to the female part of the flower. He mentions that the Pistacio has both male and female plants, and that Palms only form dates when the pollen is carried to the female tree. This experiment with the Date-palm was tried in 1592 by an Italian (Alpino) in an Egyptian tour, and the Englishman, Jacob Bobart, the Pole, Adam Zaluzianski (the latter in the same year) confirmed the general idea. Then in the year 1694 Rudolp Jacob Camerarius, a German, carried on a few more experiments, but no real definite advance was made until 1793, in the very midst of the French Revolution.[25]

The great point of Sprengel's discovery was in its being an intelligible explanation of the reason why flowers have bright colours, scent, and honey. At his time and indeed for many years afterwards, botanists looked on the stamens, petals, and other parts of the flower exactly in the way that a stamp collector looks at punctures and postmarks, that is without thinking about their meaning. Now we

[25] The historical account by Bonnier, *Cours de Botanique*, is very interesting and complete.

find that they are always designed to fulfil a perfectly definite purpose, and that all their details are contrived accordingly.

This purpose is to carry the pollen from the stamens of one flower to the stigma of another. The pollen can usually be recognized as a yellowish or reddish dust formed in the stamens; this dust is generally rubbed off on an insect's proboscis or on part of its body. When the insect reaches another flower the pollen is scraped off by a sticky or gummy stigmatic surface. When the pollen has been placed on this surface it grows, germinates, and part of it unites with the egg-cell of the young seed.

The latter is then, and not till then, able to become ripe and mature. It may be compared to cross-breeding in animals, though the process does not exactly correspond.

But all flowers do not require insects to carry their pollen. In early geological periods we do not find any flowers like those that now exist, nor in those early times were there any flies, bees, or butterflies.

The cockroach seems to have existed in Silurian (whinstone) times, and many gigantic and extraordinary insects lived in those damp forests of ferns, club-moss, and horsetails, of which the remains now form our British coalfields. Mayflies, plantbugs, and especially dragonflies (some of them with wings two feet across) existed, but none of these insects are of much use as pollen-carriers.

Even much later on, when screw pines, monkey-puzzle trees, ginkgos, and bamboos formed the forests and woods of Europe, crickets and earwigs existed; but it is not until that geological period in which the chalk was formed (the Cretaceous age) that fossil plants like most of those now familiar to us occur. These had flowers intended for insects, and with the fossil plants we find the fossils of the insects that visited them. Bees, butterflies, and ordinary flies appeared upon the scene just as soon as there were flowers ready for them. Mr. Scudder has even found the fossils of certain plants, and with them the fossils of butterflies closely allied to the present butterflies which now live on present trees allied to those fossils!

How then was the pollen of the first flowers carried?

It was in all probability blown by the wind or carried in water. Even now poplars, alders, birches, and oaks rely chiefly upon the wind to carry their pollen. These plants were amongst the first of our modern flora to appear upon the earth. Some of them possess very neat contrivances suited to the wind. The catkins of the alder, for example, hang downwards, so that each little male flower is protected from rain by a little scale or bract above it. The pollen is very light, dusty, or powdery, so as to fly a long distance. The Scotch fir (*Pinus sylvestris*) has male flowers in little cones. These are upright, and the pollen of each stamen drops on to a small hollow on the top of the stamen below. It is then blown away by the wind on a fine dry day, but it is not allowed to get out in wet weather. It is said that vast clouds of pine pollen occur in America, and that the water of certain lakes becomes quite yellow and discoloured by it at certain seasons. Each little particle of pollen has two minute caps or air-balloons which give it buoyancy, so that it can float easily immense distances.

A curious little herb, the Wall Pellitory, and another foreign species, the Artillery plant, produces small explosions of pollen. When it is touched, there is a little puff or cloud of dusty pollen. Even the common Nettle does the same on fine dry days when it is in full flower.

But of course this carrying of pollen by the wind is a very expensive arrangement. It is so much a matter of pure chance that a grain arrives at its right destination. Suppose that a flower is giving out clouds of pollen, then the chance of a pollen grain reaching a female flower only five feet away is very small, even if the stigma of the female flower is a quarter of an inch in diameter. The chance of pollen reaching it will only be about 1 to 1440; 1439 pollen grains will be wasted[26] for every one

[26] The pollen from the great pine forests of the Italian Alps blown up to the snow becomes used in nourishing the Pink or Red Snow Algæ, which colours it a delicate rose-pink. In lower grounds all such pollen becomes, like leaf-mould, a manure for other plants. There is no *waste*, strictly speaking.

that reaches the stigma. But even this is not quite a fair calculation, for if the female flower is not down wind, none will reach it at all!

But if an insect goes to the catkin of an alder or any other male flower, it will see the red points of the stigma and will very likely go there at once. This shows how much more reasonable and efficient insects will be.

The immense majority of flowers are, in fact, purple, blue, red, yellow, or white, so that they are conspicuous, and stand clearly out against the green of their leaves. It is well known to all who have arranged flowers for the table that the green of the leaves of different plants varies greatly in its shade and tint. Many greens do not match special flowers at all, but it is the fact that the green of any one plant is always quite harmonious, and agrees well with its own flowers!

Besides varied and beautiful colours, sweet or strong scents and supplies of honey or nectar are provided for insects.

How did flowers manage to produce all these attractions? No one has answered that question. We know in a general sort of way that the parts of flowers are modified leaves, and that petals and stamens become yellowish or pure white because they do not form green colouring matter like ordinary leaves.

It is also known that on the Alps or on any high mountain, where the air is pure and the sun strong, flowers become rich, brilliant, and vivid. In such places as the "Jardin" near Mont Blanc, the pure, deep, rich blue of gentians, the crimsons, reds, and purples of other flowers, impress the most casual and unobservant traveller. "White and red, yellow and blue, brown and green stand side by side on a hand's breadth of space." In that strong mountain air, also, perfumes are stronger, purer, and of finer quality than in the lowlands. There is a more intense, active, and vigorous life going on in flowers than is required by the more prosaic industries in other parts of a plant. Flowers also often live at a higher temperature than the surrounding air.

Kerner has described how the little flowers of Soldanella penetrate the snow by actually melting a passage for themselves through it (see p. 103).

This high temperature and vigorous life, shown also by the rapid transpiration of flowers,[27] seems to hint that colours and perfumes appear in consequence of rapid chemical transformations.[28]

It was, of course, by degrees that the extraordinary variation in colour, which exists in nature, came about. No doubt bees, bumble-bees, wasps, and the more intelligent flies were improved and developed æsthetically. We can almost tell by looking at a flower what sort of insect probably visits it.

Not only so, but there are the neatest imaginable contrasts and blends of colour. The common Bluebeard Salvia, e.g., has the uppermost leaves (three-quarters to an inch long) of a deep, rich, blue-purple, which the roving Bumble-bee will see from a long way off. The Bumble-bee flies to this great splash of her favourite hue and for a second buzzes angrily, then she notes the small *bright-blue* patches on the upper lips of the small flowers below the leaves which are set off by *white* hairs of the upper and *yellow* hairs of the lower lip.

That bees really do understand and are guided by colour may be gathered from the following unfortunate accident. A certain hive of bees which had been brought up in a blue-striped skep became accidentally scattered. They tried to find their way back to their old home, but many strayed, and it was noticed that they had tried to enter the doors of every blue hive, which were strewn with the bodies of the unfortunate intruders.[29]

The rich blue-purple of Aconite, the dark strong red of the Woundwort (*Stachys silvatica*) are specially beloved by bumble-bees and hive-bees. Butterflies like any bright colour. Those flies which

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[27] *Pharmaceutical Journal*, May 20th, 1899.

[28] Buscalioni e Traverso, *Atti del Ist. Bot. di Pavia*, vol. 10, 1904.

[29] Von Buttel, *Respen*.

have a long, sucking proboscis, resemble the bees in their tastes, but all these insects are quite capable of finding out where they can get honey most easily, and visit flowers whatever the colour may be.

A very strange and wonderful fact is that quite a number of plants prefer the dark, or rather the dim, mysterious light of the gloaming. Then the Honeysuckle, the Evening Campion, the Night-scented Stock, Tobacco, and Schizopetalon give out their strongest scent and open out their white flowers as widely as possible. That is because they wish to attract the owlet moth and others which come out at this time, when there are fewer enemies and more security. If you look at any of these moth-flowers at mid-day, they are for the most part closed up, they are not particularly attractive, and they are giving out very little scent. The contrast to their condition in the evening is most striking.

Not only insects but birds are used to carry pollen. The gorgeous little humming birds, with their brilliant metallic crimson, bronze-green, and purple, are of the greatest importance in the New World. In the Old World they are replaced by the tiny *Nectarinidæ* or Sunbirds, with breastplates almost as exquisitely jewelled. They prefer the most gorgeous reds and scarlets, such as that of *Salvia horminum*, *Lobelia cardinalis*, and the like. Fuchsias are regularly visited by them in Tierra del Fuego, where sometimes they may be seen busily at work during a shower of snow. In South Africa they seize the stem of a Redhot Poker (*Tritoma*) (*Kniphofia macowanii*), and twisting their little heads round, they suck the honey from every blossom in succession. Still more interesting it is to see them perched on the edge of one of those great tumbler-like heads of Protea (e.g. *P. incompta*) and dipping their slender curved beaks repeatedly into the flowers. Then the little male bird will alight on a branch and make the most elaborate preparation for a song of triumph. Although helped out by fluttering of wings and much display of feathers and tail, the song is a very faint cheep of the feeblest description, and very difficult to hear.

Not only birds but even animals are sometimes called into the service. There is a group of small mammals which live on the honey of flowers. Even the Kangaroo is said to occasionally take a draught of nectar from some of the cup-like flowers of the Australian Dryandra (*Proteaceae*).

But one of the most interesting and extraordinary facts is the manner in which flowers fit in. They begin early in the morning: one blossom opens out and then another; all endeavouring to catch the attention of some passing insect. *Allionia violacea* opens at three or four a.m., and closes about eleven or twelve. Some wild Roses open about four or five in the morning, as well as the Chicory, Roemeria, etc. Virginian Spiderwort, Dandelion, and Nightshade are ready at six in the morning. A great many (Buttercups, White Water Lily, etc.) are open by seven a.m. Most of these early flowers are shut at noon. Others begin to close about three or four in the afternoon. The regular evening moth-flowers open about six p.m., though *Cactus grandiflorus* does not open till nine or ten p.m., and closes at midnight.[30] Extraordinary as these variations seem, they are easily explained. Some open early because there are then few competitors. By far the greater number are open from nine a.m. till one or two p.m., because those hours are the favourite working time of most insects.

Flowers live for very different periods. That of the Wheat only lasts for fifteen or twenty minutes (its pollen is carried by wind), and is then over. There are others, Hibiscus and Calandrinia, which only remain open for three or four hours, but a Foxglove will last six days, a Cyclamen ten days, whilst Orchids may last for from thirty to eighty days (*Cypripedium villosum*, seventy days, *Odontoglossum Rossii*, eighty days).

Thus the sun every day through the summer, as he calls into life new swarms of insects, sees at every hour of the day new flowers opening their petals to his genial warmth and ready for the new bees and flies. The development of the flower and that of its insect are probably simultaneous, and equally regulated by the sun's warmth. Moreover the opening periods do not merely fit in during the day, but each flower has its own special month, and even in Scotland there is no month in which

[30] Linnæus and many others have made Floral Clocks. Kerner, *Natural History of Plants*, describes the opening and closing of flowers very fully.

some flower may not be found in bloom. Any stray wandering insect can get its draught of honey at any season of the year.

This is a matter of some importance for those who keep bees, and the following list may be of some use. *February*: *Crocus vernus*, Snowdrop, Black Hellebore, and Hazel. *March*: The preceding, *Arabis alpina*, Bulbocodium, *Cornus mascula*, *Helleborus fœtidus*, Giant Coltsfoot, Gooseberry, various species of Prunus and Pyrus, Willow. *April*: The preceding as well as *Adonis vernalis*, *Barbarea vulgaris*, *Brassica napus*.

It is not worth while noting those that bloom from May to September, for there are hundreds of good bee-flowers in these months. In *October*: Borage, Echium, Sunflowers, *Lycium europæum*, *Malope grandiflora*, Catmint, Tobacco, Ocimum, Origanum, *Phacelia tanacetifolia*, and others. Most of these last into November.[31] In December and January very few plants are in bloom. The following have been noted at Edinburgh Botanical Gardens: *Dondia epipactis*, *Tussilago fragrans*, Snowdrop, *Geum aureum*, Hepatica, *Primula acaulis*, *P. veris*, *Aubrietia deltoidea*, *Crocus imperati*, *C. suaveolens*, *Erica herbacea alba*, Helleborus (3 species), *Polygala chamaebuxus*, *Andromeda floribunda*; also Sir H. Maxwell[32] mentions *Azara integrifolia*, *Hamamelis arborea*, and *Chimonanthus fragrans*. Of wild plants, Chickweed, Whin or Furze, *Lamium purpureum*, and Dandelion can generally be found in the depth of winter.

The contrivances which can be found in flowers, and by which the insect is forced to enter exactly along the proper path, are endless. Each flower has some little peculiarity of its own which can only be understood by thoroughly examining the plant itself. It is not therefore possible to do justice to the ingenuity of flowers in a work of this sort. There are orchids which throw their insect visitors into a bath of water, so that they have to crawl with wet wings up a certain path where they touch the pollen masses and stigma; others which hurl their pollen masses at the visitor. In the Asclepiads a groove is provided into which the leg of the insect slips, so that it has to struggle to get its foot out, and must carry off the pollen masses, though it often fails and leaves its leg behind. Some Arums and Aristolochias have large traps in which they imprison the insects, and only let them go when they are sure to be pollen-dusted. In one of these flowers there are transparent spots on the large petal-prison, which so attract the insects that they remain opposite them instead of flying out (just as flies do on a window-pane). Salvia has a stamen which is like a see-saw on a support; the bee has to lift up one end, which brings the other with its pollen flat down on to its back. The Barberry has a sensitive spot on its stamen; when the insect touches the spot, the stamen springs up suddenly and showers pollen upon it. In Mimulus the two flaps of the stigma close up as soon as they are touched, which will be when they have scraped off any pollen; then when the creature withdraws, covered with the flower's own pollen, none of this can be left on its own stigma, as this is shut up.

But instead of reading, one should watch a bumble-bee visiting the Foxglove flowers. The sight of her busily thrusting her great hairy body into the bell, which almost exactly fits her shape, while she gurgles with satisfaction, will teach the reader far more about the romance of flowers than many pages of description. If he then carefully examines the flower, he will see how the honey, the arched converging stamens, and the style, are placed exactly in the right place and where they will have the most effect.[33]

One orchid, *Angraecum sesquipedale*, has a spur eighteen inches long, and the great Darwin suggested that there must be an insect somewhere with a tube long enough to reach the honey. Such an insect, a large moth, was actually brought home from Madagascar, the place where this orchid occurs, after a lapse of many years!

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[31] Huck, *Unsere Honig u. Bienenpflanzen*. These are drawn up for Germany, and cannot be warranted for this country.

[32] *Memories of the Months.*

[33] Compare Shelley, who watched all day "the yellow bees in the ivy bloom," but he "did not heed what things they be." Moreover, though he appreciated the general spirit of the bee, it is very unlikely that he saw any of them on the Ivy!

Perhaps more remarkable than anything else are such cases as the Yucca and the Yucca-moth or the Fig-wasp and the Fig.

The Yucca is a fine lily-like plant resembling the Aloes in general appearance. A particular sort of moth lives entirely upon the Yucca. When the flowers open, the mother-moth kneads up a ball of pollen and places an egg inside. This ball she thrusts down the style into the ovary of the flower. There a grub develops from the egg and eats the pollen, yet some of this pollen fertilizes the young seeds. If Yuccas died out the moth would be exterminated. If the moths were destroyed, no Yuccas would ever set their seed!

The Fig has two sorts of flower. The one (caprifig) produces only male or pollen-yielding flowers. The other is the true edible fig. Inside the caprifig are the grubs of the fig-wasp, which rejoice in the name of *Blastophaga grossorum*. When grown up these force their way out of the caprifig and, flying to the true fig, the mother-wasp lays her eggs in certain flowers which have been apparently specially modified for the purpose. At the same time she covers the ordinary flowers with pollen from the caprifig. Her progeny return to the caprifig. Here again the future of a valuable fruit-tree is absolutely bound up with the fortunes of a tiny and in no way attractive wasp!

Another very remarkable case is that of those flowers (Stapelia, etc.), which in colour and general marking closely resemble decaying meat or other objectionable substances. Very often the smell of such flowers is exceedingly strong, and resembles the ordinary smell of putrid matter. In one case an artist employed to paint the flower had to use a glass bell, which was put over it. He could only lift it for a second or two at intervals in order to see the exact colour, before the horrible odour obliged him to cover it over again. Blowflies and others, which are in the habit of resorting to such substances, seek out these flowers in great numbers and lay their eggs upon them. In so doing they carry the pollen.

There are certain fungi which have quite as horrible a smell, and some of them also resemble decaying animal matter. These are most eagerly sought out by the same blow-and other flies (bright green lucilias, yellow-brown scatophagas, bluebottles, etc.). But in the case of these fungi it is the spores, not pollen, which is carried by the insect.

The effect of this flowery sort of life is abundantly evident in the structure of the insects themselves. Their mouth has been most wonderfully modified into a complex sucking apparatus; their legs have been transformed to act as pollen-carrying baskets, and the habits and tastes of the insects have been modified in the most extraordinary way.

Perhaps also the association of bright colours with a very pleasant sensation – that of a full, satisfying meal – has raised the artistic sensibilities of butterflies, sunbirds, humming birds, etc. For certainly these flower-haunting birds and butterflies are remarkable for their brilliant colouring. This has probably been brought about by the preference of the females for the most brilliantly coloured male butterflies and humming birds.

At any rate bright reds and blues are common to both bird or insect and to the flowers that they frequent. But the most curious point of this whole question lies in the fact that human beings of all grades, South Sea Islanders, the Ancient Greeks, Peruvians, Japanese, Romans, as well as the Parisians and Londoners of to-day, appreciate the beauty of colouring and grace of form which are so obvious in the world of flowers.

Yet man has had nothing whatever to do with the selection of either these colours or shapes. Many of those which he considers most precious (such as the weird, spotted, and outlandish Orchids of Madagascar and South America) have very likely scarcely ever been seen by man at all. It is to the artistic eye of the honey-bee, bumble-bee, butterfly, and of the humming bird and sunbird, that we owe these exquisite colours. The grace and beauty of outline probably depend upon their perfect symmetry and on the perfect suitability of every curve to its purpose.

Therefore it seems that the eyes of man, whether savage or civilized, are pleased and comforted by these same colours that delight the little brains of insects and birds.

This is indeed a mysterious fact.

CHAPTER VI
ON UNDERGROUND LIFE

Mother-earth – Quarries and Chalk-pits – Wandering atoms – The soil or dirt – Populations of Worms, Birds, Germs – Fairy Rings – Roots miles long – How roots find their way – How they do the right thing and seek only what is good for them – Root versus stones – Roots which haul bulbs about – Bishopsweed – Wild Garlic – Dandelion, Plantain – Solomon's Seal – Roots throwing down walls – Strength of a seedling root.

THE word "Adam" means red earth. Poets and essayists still regularly write about Mother-Earth and, in so doing, admit one of the most interesting and wonderful facts in Nature.

If you go to some quarry or cliff where a section has been cut, laying bare the original rock below; then (with Hugh Miller) you may reflect on the extraordinary value of those few inches of soil which support the growth of all our trees and of all our cultivated plants.

It is probable that plant-roots *never* go deeper than about thirty feet. All our food, our energy, and activity depend therefore on this thinnest surface-layer of an earth which is 8000 miles in diameter. But in most places the depth of true soil is far less than thirty feet, generally it is not more than thirty inches, and by far the most valuable part of it is a very thin layer five or six inches thick.

It is in this true soil that the roots gain their nourishment, and not only roots, for whole populations of worms, of germs, of insects, even of birds and the higher animals, live upon it. To it return the dead leaves, the bodies of dead insects, and waste products of all kinds. Within it, they are broken to pieces and worked up again by the roots of other plants in order to form new leaves, new insects, and food for bird and beast. Just as in engine-works, you may see old engines, wheels, and scrap-iron being smashed into pieces; they are melted down and again worked up into engines of some improved design.

On a chalk-cliff, which dates from the long-distant Cretaceous period, the entire thickness formed by the yearly work of plants for millions and millions of years is often less than a foot in depth, and probably only four to five inches are true soil.

But this is an exceptionally thin stratum, although it is capable of producing rich turf, fat snails, and excellent mutton. In peat-mosses and in those buried forests which form the coalfields, vegetable matter may accumulate in deposits of thirty feet of coal. Yet these stores of carbonaceous matter seem to be at first sight miserly and selfish, at least from a vegetable point of view.

They resemble the gold and silver withdrawn from circulation in the world by some Hindoo miser and buried deep within the earth. Yet somebody is pretty certain to find out and make use of such stores eventually.

In the case of the peat and coalfields, an animal of sufficient intelligence to utilize them has already been produced, and now they are used by man as fuel.

It is very important to remember that the soil is a sort of last home to which the particles of carbon, of nitrate, and minerals always return after their wanderings in the bodies of plants, of insects, or of other animals. They probably rest but a short time before they again set off on new adventures.

One might say the same of the water, and of the carbonic acid gas and oxygen of the atmosphere, for the water, falling as rain upon the earth, trickles down to the underground water-level. Then it immediately begins to rise up between the particles of earth and is promptly caught and sucked in by the roots, only to be again given out by their leaves. The carbonic acid gas and oxygen also are always entering and leaving the foliage. Even the nitrogen of the air is not left alone in the atmosphere. There are small germs in the soil which are able to get hold of it and make it into valuable nitrates.

More curious still is the fact that electric charges can be used to change the comparatively useless air-nitrogen into useful manures. Probably the farmer will some day make his own nitrates by electricity.

The structure of the soil or earth is a most interesting and romantic part of botany. It is true that a "radical" disposition is necessary if one is to go to the root of the matter, but, unless we do this, it is impossible to realize the romance of roots.

Down below is the unaltered rock, sand, or clay. Next above it comes the subsoil, which consists of fragments of the rock below, or of sand, clay, etc., more or less altered by deep-going roots. Even in this subsoil, bacteria or germs may be at work, and the burrows of worms and insects often extend to it. Next above the subsoil comes the true soil; there is plenty of the stones, soil, sand, or whatever it may be that constitutes the subsoil, but its richness consists in its contents of valuable minerals, and especially of broken-up leaves, corpses of insects, and manure. Above this true soil are first the leaf-mould of two years ago, then that of the year before last, and *on the top* is the leaf-mould and other decayed products of last winter.

All these upper layers are full of life and activity, which probably goes on vigorously all the year round.

The population of worms is especially important. The worm is a voracious and gluttonous creature: it is for ever swallowing bits of leaves and rich soil. Inside its body there are lime-glands which act upon the vegetable food and improve its quality as manure. The worm comes up to the surface at night or early morning and leaves the worm-casts upon it. The rain then washes the rich, finely-divided matter of the casts down into the soil again. It is said that there are about 160,000 worms at work in an acre of good soil. Yet their life is full of danger. A keen-eyed population of blackbirds, thrushes, starlings, peewits (plover), and partridges are always watching for and preying upon the poor worm. Even in his burrows, which may be six feet deep, he is not safe, for the mole (*moudiewarp*) is also both very hungry and very active, and delights in eating him.

In the soil also and even deeper in the subsoil are many insects; some hibernate in the winter, and at other times actively gnaw the roots of plants or devour dead leaves and twigs (see Chapter xxiii.). Thus there are many burrows and holes, so that there is no want of air in the soil, which is indeed necessary both for these creatures and also for the roots of the plants.

Rain comes down through the soil, carrying with it carbonic acid, mineral salts, and also germs or bacteria, which form perhaps the most important population of all.

No work could be carried on without their help; it is bacteria which, at every stage of decay, assist in breaking up leaves, twigs, insects' bodies, worm-casts, and other manures. The way in which they work is too difficult to explain here, but to get an idea of the romance of the underground world one must try to picture to oneself these swarms and myriads of germs and bacteria all incessantly and busily engaged at their several duties. In the uppermost layers there are probably in a single cubic inch of good soil from 54,000,000 to 400,000,000 of these microbes. Many are absolutely necessary to the harvest; a few may be of little importance, but there are sure to be some of those dangerous sorts which might devastate a continent with disease in a single summer.

There are also quantities of other fungi. The fairy rings which one sees year after year in widening circles of bright, fresh green are the work, not of fairy footsteps, but of an underground fungus (*Marasmius oreades* and others). Its threads are thin, white, and delicate; they attack the roots of grasses, etc., on the outer side of the ring. It is therefore on this outer side yellow, dry, and more or less withered. On the inner side, however, the grass is luxuriant and of a rich bright green. Here the fungus has died off, and its remains, as well as those of the plants which it destroyed, form a rich manure for the new grass following on its track. Every year the ring widens; at a certain time in summer one sees the irregular line of mushroom-like fungi which are formed by the destructive underground absorbing threads. This, however, is but one of the underground fungi. There are many kinds; some are useful, others are very destructive.

Upon the upper surface of the soil there falls not only rain, but another sort of rain consisting of seeds, dead leaves, insects' bodies, fungus spores, bacteria, and dust.

Every year when the ploughman turns the sod there is a revolution in the whole of these populations.

So far nothing has been said about the roots themselves, which penetrate, explore, and exploit all these layers of dead leaves, soil, and subsoil.

The length of roots produced is very much greater than any one would suppose. A one-year-old Scotch fir seedling when grown in sand produced in a season a total length (branches, etc.) of no less than thirty-six feet of root. The total surface of this root system was estimated to be about twenty-three square inches. This little Scotch fir after six months' growth was laying under contribution a cone of earth twenty to thirty inches deep and with a surface of 222 square inches. In certain kinds of corn the same author estimated the total length of the roots as from 1500 to 1800 feet. S. Clark estimated the length of the roots of a large cucumber plant as amounting to 25,000 yards (fifteen miles), and made out that it was occupying a whole cubic yard of ground.

Clover roots are said to go down to depths of six or nine feet, but many weeds go deeper still. Coltsfoot, for instance, may be found, according to a friend of mine, living at a depth of twenty spades. In Egypt and other places the roots of acacias go down to twenty feet or even further, so that they can tap the water supplies, which are at a great depth.

But a still more extraordinary fact is the manner in which the root-branches arrange to grow in such a way that they search every part of the soil.

The main root in many plants grows straight down, or as nearly as it can do so. Its branches are inclined downwards at a quite definite angle which is often 30°-45° to the surface. Moreover, these branches come off in quite a regular way. Each keeps growing in its own special direction to the east, south-east, or west, or whatever it may be, of its parent root.

Have they some extraordinary sense of the direction of the points of the compass? It is said that if a side root, which is growing, say for instance downwards and westwards, is turned in some other direction, it will after a time resume its original westerly voyage. This fact is a most extraordinary one, if true, but it can scarcely be said that it has been proved, and, as will be shown later, there are other curious facts in the behaviour of roots which might explain the experiment without assuming that roots know the points of the compass.

If one cuts a branch of willow and plants it upside down in the earth, it will very likely take root and grow. Its appearance will be most extraordinary, for the roots will grow downwards, whilst the branches, instead of growing in the direction of the old branches, turn round and grow upwards.[34]

Why do roots generally grow downwards? The fact is so familiar that the difficulty of answering does not, at first sight, seem so great as it really is.

Pfeffer, the great physiologist, has the following interesting comparison. Suppose a man is trying to find his way in the dark, then a single lingering ray of light gives him an impulse to walk towards it.[35] So our root, also in the dark, feels the pull of gravity and endeavours to grow downwards. Others have compared the direction of gravity to the sailor's compass, and suppose that the root is guided in the same sort of way.

But a young, vigorous root making or forcing its way in darkness through stones and heavy earth is a most interesting and fascinating study.

There are the most extraordinary coincidences in its behaviour. It has the property of always doing exactly the right thing in any emergency.

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[34] Kerner and Oliver, *l. c.*, vol. 1, p. 88.

[35] *Annals of Botany*, 1904.

It is of course intended to keep below the ground and in the dark. So we find that if roots are uncovered, they will turn away from the light and burrow into the earth again. They avoid light just as a worm would do.

Roots are of course intended to absorb or suck in water. If there is a drain in the soil or a place where water collects, the roots will grow towards that place. Very often they form a dense spongy mass of fibres which may almost choke the drain. Along a riverside one can often find great fibrous masses of tree roots near the water. But how does the root learn that the water is there and turn away from its original track to find it? It certainly does so!

Then again, Herr Lilienfeld has recently shown that roots seem able to turn away from poisonous materials in the soil and to seek out and grow towards valuable and nutritious substances. He found that peas, beans, sunflower, and other roots were very sensitive to different substances in the soil, and were directly attracted by what was good for them and turned aside from what was unwholesome.

This property and the power of growing towards water probably explain the mysterious sense of direction alluded to above, for roots will take a line which has not been exhausted by their neighbours.[36]

But of all these wonderful properties, the most remarkable is the way in which roots find their way past stones and other obstacles in the soil. They insinuate themselves into winding cracks and crawl round stones with an ingenuity that makes one wonder if they can possibly be without some sort of intelligence.

It is the very tip or end of the young root that seems to be responsible; for if, in the course of its journeyings underground, it should strike a stone or something hard, the root does not grow on and flatten itself.

But some sort of message is sent back from the tip to the growing part which is a short distance behind it. After this message has been received, the growing part begins to curve sideways, so that the tip is brought clear of the obstacle and can probably proceed triumphantly upon its way. The inexplicable part is that the growing part which curves has never been touched at all, but simply answers to the message from the tip.[37]

This is perhaps the most reasonable and intelligent behaviour found in the whole vegetable world, and it is not surprising that Darwin compared the root-tip to a brain.

These extraordinary responses fill one with astonishment, but there are others still more interesting and remarkable. It will be remembered that we have already shown how different the soil is at different levels. The subsoil, soil, and uppermost layers are all quite different from one another.

This may explain why it is that many plants seem to prefer to develop their roots at one particular depth below the surface. Not only so, but they find their own favourite level in the most persevering way.

If, for instance, you sow a barley-corn at too great a depth, the seed germinates and forms a few roots, but it immediately sends out a stem which grows upwards towards the light. As soon as this stem has reached the proper place, which is just below the surface, there is an enormous development of roots, which begin to search and explore their favourite stratum of soil.[38]

In some few cases one can see in a dim sort of way the reason for the level which certain plants prefer. Thus the underground stems of the common Thistle, which are very long and fleshy, are found just a few inches below the level usually reached by plough or spade. This makes it very difficult to tear them out. Even if grubbers with long spikes which reach as deep as these buried stems are driven through the ground, it generally happens that the stems are only cut in pieces and not dragged up.

[36] Lilienfeld, *Beihefte z. Botan. Centralblatt*, Band XIV., abth 1, pp. 131-212. The facts were denied by Newcombe and Rhodes, *Bot. Gazette*, 36, 1904.

[37] If the growing part itself touches a stone it curves round the stone, not away from it – the reverse of the reaction at the tip!

[38] Pfeffer, *l. c.*, p. 139.

These hardy weeds are not much injured by little accidents of this kind, for each separate bit will form upright thistle stems next year. In fact if one cuts this fleshy subterranean runner of the Thistle into pieces a quarter of an inch long, each piece will probably become a Thistle.

Sometimes indeed these weeds are carried from one field to another by pieces of them sticking in the very machines which are used to eradicate them.

The Bishopsweed is one of the hardest cases. The writer was once ambitious enough to try to dig up an entire plant of this horrid weed. The first foot or so revealed no sign of the end of the branching runners, and it was not until a hole about four feet deep and five feet across had been excavated that there was any sign of an end to the plant.

When it was at last removed, the original deeply buried stem was found to give off branches which again branched in a most complicated manner, until almost every green shoot of Bishopsweed[39] within a space six feet in diameter was seen to be really a branch of this one original plant! So to eradicate the plant it would have been necessary to dig over the whole garden to a depth of at least five or six feet.

How did the stem get down to such a depth below the surface? This is one of the most curious stories in plant life, and the process which we shall now try to describe has only been explained within the last few years.[40]

The seed of the Wild Garlic (*Allium ursinum*) lies at first upon the surface of the ground, but it is soon buried by a growth of the stalk of the seed-leaf, which pushes the germ down below the earth. As soon as it is buried, roots are formed and pass obliquely downwards, where they become fixed by forming root-hairs all round themselves. These root-hairs round every root hold its tip firmly in the earth; then these same roots contract or shorten, which of course hauls down the root a little deeper in the earth. One might compare it to a few men hauling down a balloon by ropes attached to the car. About September to November, roots of quite a different character are formed; these explore the surrounding soil and gather in food and moisture.

Then the roots rest during the winter, when the buds and young leaves are being formed. In April the buds begin to push out their leaves and a new ring of roots appear. These April roots are quite different from the September ones. They again fix themselves firmly and then contract, becoming fully a third shorter than they were originally. The bulb is dragged down still deeper below the surface. It flowers in May and fruits in June and July. Then in September the same series of operations begins again. The process goes on until the plant is three to five inches below the ground.

It follows from all this, that every year the roots find new ground to explore and utilize. Nor is the Wild Garlic at all exceptional in this respect. A great many plants have roots which contract and drag the bulb or stem after them deeper into the earth. Something of the same sort happens, for instance, to Bramble branches. They arch or droop over, when growing, so that the end touches the earth. On the underside of the tip, as soon as it begins to rest on the ground, roots are formed. These roots make their way into the ground, and then, when fixed, they shorten or contract, so that the end of the branch is dragged down to a depth of several inches. After this has happened the old branch generally dies away, and a young, vigorous Bramble develops from its buried tip.

Raspberry branches also are often buried; their roots become coiled or rolled in a very curious manner. The end of the root becomes firmly attached in the soil, and then the rest of it revolves like a tendril so as to draw the stem deeper into the earth.[41]

On any ordinary roadside in the country one is sure to find the rosettes of the common Dandelion and of the Rats-tail Plantain (*Plantago major*). These are two of the most interesting plants

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[39] This weed is a cure for gout, and seems to have been called Bishopsweed because it was supposed that gout was a common ailment of bishops!

[40] By the classical researches of Rimbach.

[41] Scott Elliot and Fingland, *Trans. Nat. Hist. Soc. Glasgow*, vol. 5, New Series, part ii., 1897-8.

in the world, although they are vulgarly common. How is it that their leaves are always at the level of the ground? The stem is always growing upwards; every year fresh circles of leaves are formed above the older ones. Yet the crown of the stem is never so much raised up above the ground that the toe of a boot would be likely to knock it off. It is always kept so deep in the earth, that it is by no means easy to kick or "howk" the crown out of the ground.

The Dandelion root contracts very strongly at the end of the season, and by this shortening or contraction keeps its leaves just at the soil level. The Plantain sends out about forty to sixty oblique downward-growing roots, which fix themselves in the soil by throwing out branch roots. These forty to sixty roots are at first about ten inches long, but, as soon as they are firmly attached, they contract, and pull the stem with its crown of leaves about one-third of an inch deeper. This is just enough to keep the leaves flat on the ground and to prevent any possible injury from passers-by.

So that in finding their favourite level in the soil, plants are often pulled or hauled about by the roots. But they are not always moved by the roots. Even though buried in darkness, they seem able in some way to tell when they are in the most favourable position.

Every gardener knows that Autumn Crocus and other bulbs do not remain in the same position. They wander below ground in a curious and inexplicable fashion.

The Solomon's Seal has an underground, fleshy stem, which prefers to grow at a definite depth. If it is planted close to the surface, then the point of the next year's little fleshy bud turns downwards; next year it again turns downwards, and so on every year, until the stem has reached its proper depth. Then it grows horizontally. Similarly, if it is planted too deep it grows upwards.

Thus if one wishes to realize the underground life of plants, one must picture to oneself: —

1. The usual descending roots, whose system of branching may be compared to the ordinary branching above ground. It is often not unlike the reflection in water of the tree itself, such as one might see on a fine winter's day along the shore of some still lake.

2. The bold, exploring, horizontal runners of Couchgrass, Thistle, Bishopsweed, etc., vigorously pushing their way at a depth too great for the gardener's spade.

3. All sorts of bulbs, runners, and roots being slowly hauled or dragged about till they get into exactly the right position, but never remaining for two years in exactly the same place. All have their favourite depth[42]—

Herb Paris	2/3 to 1-3/4	inches deep.
Solomon's Seal	1-1/3 to 2-1/3	" "
Cuckoo Pint (*Arum maculatum*)	2 to 4	" "
Colchicum (Autumn Crocus)	3-1/3 to 5-1/3	" "
Asparagus	6-3/8 to 13-1/8	" "

The water evaporating on the surface of the soil must, as it rises from the permanent water-level below, pass the gauntlet of all these thirsty rootlets and their hairs. Tree-roots will be ready to intercept it at ten feet depth, many herbaceous plants will suck it in at depths of five to six feet, and in the upper layers of soil it will have to pass root-system after root-system from Asparagus to Paris, so that very little will be lost.

Perhaps of more importance are the bacteria-germs, and dissolved mineral salts in the rainwater as it trickles down from the surface. The soil particle acts as a filter: at every inch of the descent some of the bacteria and salts will be left, so that by the time the level of Asparagus has been reached there will be exceedingly few, and the water is comparatively speaking pure. The effect of this vigorous underground life is often visible on the surface. Roots, and particularly tree-roots, are

[42] See Rimbach's researches.

often extraordinarily strong. Kerner, in his invaluable *Natural History of Plants*, has a beautiful picture of a young larch tree which had grown in a fissure of a huge boulder.

In attempting to grow, the root had forced up part of this stone. It was estimated that it had lifted a weight of 3000 lb., though it was only some ten inches in diameter.

Along a dry-stone wall, or even near houses, the growth of tree-roots very often damages the entire wall, which may be entirely overthrown if the tree is too near. The force of the growth of the roots is so great that even a six-foot stone wall cannot keep them down.

Quite a young seedling root, in forcing itself through the soil, may exercise a pressure of two-thirds to four-fifths of a pound!

This is of course necessary, if one remembers that it has to drive itself through the earth, pushing aside and compressing the earth particles along its course.

CHAPTER VII
HIGH MOUNTAINS, ARCTIC SNOWS

The life of a cherry tree – Cherries in March – Flowering of gorse – Chickweed's descendants – Forest fires in Africa – Spring passing from Italy to the frozen North – Life in the Arctic – Dwarfs – Snow-melting soldanellas – Highland Arctic-Alpine plants – Their history – Arctic Britain – Edelweiss – An Alpine garden.

IT is impossible to understand and very difficult to explain the sort of life and consciousness which is enjoyed by plants.

That they do live is obvious; we know instinctively that they enjoy fine weather in summer and gentle showers in spring, but we cannot prove it.

Much of a plant's life is concealed and hidden from us. Even the few explanations which have been given by certain observers are by no means generally accepted.

This is true even as regards the case of the Cherry tree, which has been experimented with, and fought over and argued about by botanists, and yet we only know a very little about its inner life.

When the leaves fall in autumn, next season's buds are already formed and are then about one-eighth of their full size. At this time the tree contains enormous quantities of food-stores, for the whole season's work of the leaves has been accumulating until this moment. During the long winter's "sleep" the tree is by no means at rest. It is arranging and packing up those stores in the safest place and in the most convenient form.

Just as a bear, before it retires to sleep during the winter, takes care to get as fat as possible, so the Cherry turns its starch to fat, and stores it away in the innermost and least exposed parts of the tree, that is in the central wood. As soon as the winter ends, and indeed *before* it has ended, preparations are beginning for the great moment of the year. For weeks there is a slow, gradual, almost imperceptible growth of the buds, then they develop with a rush, and in six to ten days double or treble their weight. Then comes the supreme moment, for the flower-buds suddenly burst open and the Cherry is in active and vigorous bloom and covered all over with exquisite blossoms. All last year's fats and starches are rapidly used up. Very soon the young leaves are beginning to make sugar and other food, which give some help during the ripening of the fruit.

The flowers are actively at work. One of our usual misconceptions as to the nature of a flower is that it is an emblem of peace, of restful enjoyment, of serene contemplation of its own beauty. That is very far from being the truth. The petals are actively, vigorously working. If one could take the pulse of a petal, which shows the rapidity of its breathing, one would find that it is twice as fast as that of the leaf. The work of changing water into vapour and pouring it out goes on three times as quickly in the petals (as compared with the leaves). Moreover their temperature is higher, and often distinctly above that of the atmosphere.

This feverish activity of the flowers themselves is matched by the hurrying crowds of excited and exhilarated insects which are searching every blossom.

No wonder that the Japanese Prime Minister, in the midst of their great and famous war, invited the whole cabinet to spend an afternoon watching the cherry trees in bloom!

From the blossom of the springtime all through summer and autumn follows one continuous spell of hard work. Day after day an endless stream of food is entering the stem; night after night it is condensed and arranged and repacked, until, when the leaves fall, the period of slow and quiet preparation begins again.

Under certain conditions it is possible for gardeners to modify the life of a cherry, and to make it bloom much earlier, but this is only possible within well-defined limits. It is no use trying to force it to bloom before January. It *must* have a quiet time after summer. But by beginning in January and by very carefully managing the temperature, it can be made to produce fruit quite early in the year.

The following account is given to show how very carefully gardeners have to work when they upset the ordinary course of Nature's events. The plant is taken into a greenhouse, and the temperature kept as follows: —

	Day Temperature.	Night Temperature.
First week	48°-50° F.	41°-45° F.
Second week	50°-53° F.	45°-48° F.
Third week	53°-59° F.	48°-51° F.
Till flowering	59°-64° F.	51°-57° F.
Flowering period	46°-53° F.(!)	43°-50° F.(!)
After flowering	59°-64° F.	51°-57° F.
During development of stone	53°-59° F.(!)	48°-51° F.(!)
After development of stone	61°-66° F.	53°-59° F.
Ripening of fruit	68°-70° F.	59°-63° F.

Not merely strong, forcing heat, but a little judicious cold, is necessary to get out the flowers and to ripen the fruit.[43]

Most flowers have very much the same general history as the cherry, but it must not be supposed that they are all alike. The differences are very interesting and curious.

Thus, for example, plants of our common Gorse, furze, or whin may be found in bloom at almost every season of the year. There are at least four seasons when there is that tremendous display of golden blossom which made the great Linnæus fall on his knees and burst into tears. These are about the 22nd March, 24th May, 15th August, and 21st November; yet there are enough odd flowers blooming in almost every month to give some cause for the saying, "The gorse is out of bloom when kissing is out of favour." The last practice, though uncleanly and dangerous, not only on general grounds, but on account of bacterial germs which may be transferred, has been authoritatively condemned in the United States, but it is still more or less popular in other countries at all seasons.

The Chickweed and some other of our annual weeds show a hardy disregard of climate. Its seeds germinate and grow at any time, so that flowers and seeds can be formed whenever there is a spell of favourable weather. Now one chickweed can produce 3000 seeds. Suppose that there are only five generations in the year, which is a very low estimate. Then one seed of chickweed might produce 3000 × 3000 × 3000 × 3000 individuals in one season!

Other plants show much the same tendency. In fine warm autumns a great many annuals bloom a second time. It is on record that forty-four spring species bloomed in one warm November. At the Cape and in other warm climates many of our annuals do not die at the end of autumn, but go on growing. They become perennial.

It is even possible to make a Tree Mignonette by pinching off the flower-buds, though this plant is usually an annual.

In fact plants are not absolutely confined to one rigid scheme, but they can alter and modify their blooming time if they find it convenient to do so. In the Mediterranean some blossom in early spring and others in late autumn, whilst in the dry, hot, and dusty summer very few flower.

In Central Africa during the dry season forest fires are by no means rare. The trees are scattered, and the ground is only covered by dried and withered grasses and sedges. One sees in the distance a rolling cloud of smoke, and soon one comes to a line of flame. It is not dangerous, not even very impressive, for a jump of three feet carries you over the flame and on to a desolate wilderness of

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[43] Schimper, *Pflanzengeographie*. The account is based on the works of Pynaert, Sachs, Askenasy, etc.

black cinders, out of which stand up the scorched trunks and half-burnt branches of gaunt, naked trees. A day or two afterwards, bright blue and white and yellow flowers break out of those scorched branches and also from the ground.

It is difficult to understand why this happens, but certainly it is good for the flowers, which can be seen by insects from a long distance.

But these are unusual cases. Generally the warm breath of spring wakes up the bulbs and buds, and one after another has its moment of flowering.

Spring travels towards the North Pole at an average rate of four miles a day.

A pedestrian visiting Italy in the end of January might follow the spring northwards, and if he wished to accompany it all the way, it would be quite possible to do so without exceeding an ordinary day's march. He would have to reach North Germany by the end of March, Sweden in May, and by the end of June and July would find spring beginning in the desolate Arctic regions.

Of course the presence of mountains would make this tour a little difficult and devious, but still it is quite a possible undertaking. It would be very interesting, for he would be able to watch the cold and frost and chilliness of winter disappearing as the sun's rays thaw out a greater and greater extent of the cold and frozen North.

The life of an Arctic plant is truly set in the midst of many and great dangers.

Конец ознакомительного фрагмента.