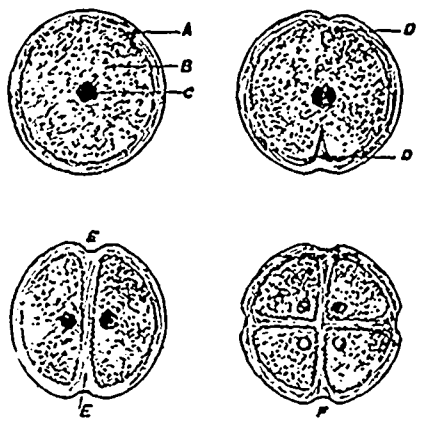
HOW TREES GROW.

By John Black.

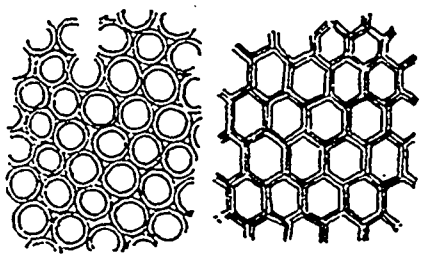
BEFORE attempting to offer an explanation of the curious processes whereby trees develop in stature, it will be necessary, in the first instance, to briefly describe the nature of the materials of which they consist, as well as to shortly notice the intimacy with which the latter are associated with and depend upon each other. In the first place, there is a structural peculiarity which is not only common to all trees but to all plants—from the tiniest mosses to the most gigantic trees of California, which often exceed 400 feet in height—and which comprises a complex system of cells or vesicles of which all vegetable growths are composed. These cells, as the name imports



SECTIONAL STRUCTURE OF CELLS.

are minute, bladder like cavities, bounded by fibrous walls and usually containing both fluid and solid matter of a heterogeneous composition. These and their numerous modifications may be very aptly compared to the bricks or stones of which a house is built, but with this remarkable difference, that they are continually dividing and sub-dividing and are constantly being supplied with fresh layers of what corresponds to cement as long as the life of the plant endures. The microscopic examination of a thin shaving of any vegetable product, whether it be the pulp of an orange or the pith of an oak, will give the best idea of the general appearance of these formations. Geometrically they are infinitely varied in form, owing to mutual pressure and other causes, but the designs that are of most frequent occurrence in the vegetable world are illustrated on this page. And just as they are of no uniform shape, neither are they of any regular compass. In fact, they alternate in magnitude in different plants from about the thirteenth of an inch to the forty-thousandth of that measurement. In order to understand the process of growth or, rather, of the multiplication and expansion of these animate organisms, it is desirable that an examination of the structure and functions of what are known as the "active cells" should first be made.

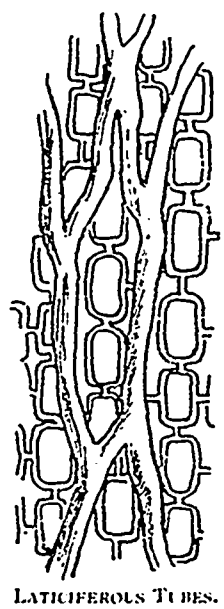
First, there is an outer covering, the cell wall, which is more or less elastic and which varies in thickness and density. In its earlier stages it is soft in texture and freely permeable to water. Inside there is a softer and more elastic layer, technically called "primordial utricle" or vesicle. The latter is scarcely membraneous like the



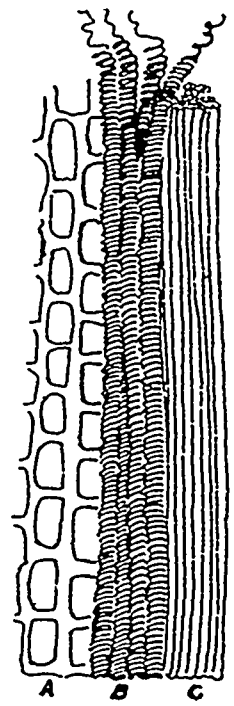
PITH CELLS.

cell-wall, and is merely the outer film of the softer matter called protoplasm. In the latter there is usually, but not invariably, present a small globular body called the nucleus, which, in turn, often contains smaller granules called nucleoli. The accompanying figure will enable the reader to understand these structures and their relative positions more clearly. The most important of these granules contain the green coloring matter which is so freely distributed throughout the composition of tree foliage, and when they disappear the activity within the cell walls diminishes and the tree becomes correspondingly lifeless. When the protoplasm is present in what may be called a healthy condition, these granules can often be seen moving about from point to point in a manner which strongly suggests the circulation of the blood in animals. The regularity of this movement of the fluid contents of the cell-sap can be distinctly seen with a powerful microscope even in the case of so minute an object as the hair of a common nettle. The formation of new cells begins by a change in the protoplasm, the whole of which or a part only may be concerned in the production of such new cells. By the division of this substance, which has been called "the physical basis of matter," into new cells, and their subsequent alteration, the mass of the entire plant is built up. Some of the simpler forms of trees and plants readily illustrate the way in which the protoplasmic contents of a cell give rise to fresh cells. In certain of these, as shown in Fig. 3, there is a general infolding or splitting up of the cell at two or more opposite points, which finally results in the production of an equal number of new and distinct cells, each with its proper complement of walls, nucleoli, &c. As the new walls develop which separate the individual compartments, the lines dividing the latter become more clearly defined, and this intercellular substance, or vegetable cement, is the material by which the cells are bound together and which permits of their subsequent division and expansion.

The process of growth in nearly all the higher forms of trees necessitates changes at certain points in their structure into string-like fibres or sinews to lend strength and support to the softer parts. This is easily seen when a leaf is reduced to the form of a skeleton by maceration or any similar means that will reveal the beauty and variety



LATICIFEROUS TUBES.



FIBRO-VASCULAR BUNDLE.

of its framework. If the stems of some of our larger ferns are treated in the same way they will exhibit, under the microscope, an amazing labyrinth of network, called "fibro-vascular bundles," as shown, which are the same in principle as those met with in the case of their sturdier brethren, the trees of the forest. In such a bundle of fibres there are generally two modifications—one called bast, a, and the other what is virtually known as wood, b. In the earlier stages these vascular bundles are composed of ordinary cells, by the transformation of which they are produced, the bast layer being usually on the outside in the case of trees proper, and the cells which continue in an active state lying between it and the inner wood. Without entering into details, it may be sufficient to state that the parts of a vascular bundle are either true vessels or merely fibrous. The former consist of long cells in rows one over the other, the partitions between their ends partially or entirely disappear and so form continuous tubes, the most notable of which have a spiral band in the interior, either continuous or broken up in places, and closer or wider apart in different cases.

The other fibrous portions of a bundle are long, spindle shaped, and without spiral bands. They often contain grains of starch, sugar, gluten, etc., and are readily detected when the wood is cut into very thin slices. The laticiferous tubes are a very interesting modification of the true vessels of this vascular system, because they contain a limpid or milk-like juice, and are in other respects a curious blending of the principles carried out in both the lacteal and blood vessels of animals.

Certain chemical changes always take place during growth. Water, so necessary for life in the plant, consisting as it does of the two gases, oxygen and hydrogen, yields supplies of these, and is also the medium by which other matters dissolved in it are conveyed to the tree or plant. The more important and life-sustaining of these are carbon, oxygen, nitrogen, hydrogen, and such other requisites as potash, lime, magnesia, phosphorus, and silica. The operation of such external influences as light and heat are just as important to the well-being of trees as the more material elements which are absorbed into their composition. The stimulus of light on the green contents of their leaves is necessary for the formation of new products and for the storing up of these in their internal recesses, for when a full supply of these is deposited in the cells there is less necessity for the action of light itself. The presence or absence of the latter has also a considerable influence upon the movements of the grains of chlorophyll. In darkness, more or less dense, these collect into bodies and display a degree of inertness which, if sufficiently prolonged, would lead to the eventual withering away and utter destruction of the tree; the phenomena presented being, in fact, almost precisely similar to what would inevitably occur in the case of an animal whose circulation, having become impaired, ultimately ceased altogether. There is still some difference of opinion as to whether those green granules are endowed with voluntary motion or whether they are carried about by some equally unknown property possessed by the fluid in which they float. The combination of light, heat and moisture enable a tree to produce new products from carbon, nitrogen, oxygen, etc., which are technically known as albuminoids, and which yield material in abundance for sustaining its life. When the juice of a plant is heated, part of it coagulates, just like the white of an egg, called albumen, when treated in the same way, and this has been extracted from the earth from many substances and converted by the instrumentality of the tree into its albuminous form.

Evaporation of water from the leaves of a tree determines the absorption of fluid by its roots, and its subsequent diffusion throughout the tissues of the plant by osmose—that is, the tendency of fluid matters to mix and combine in equal proportions when they come into contact. New cells are then formed by the division of the protoplasmic matter, as already described, and the succeeding alterations they undergo, as they are repeatedly subdivided, build up the separate organs which collectively constitute the entire tree. The rate of growth of certain trees is a subject of much interest and importance to both forester and carpenter. A cross section, cut at the base of the stem, shows a central spot—the pith—and, arranged concentrically, a number of layers, called the "annual zones," marking the growth of each year, surround this point. The exact age of a log of timber can thus be ascertained (when the date of its being felled is known), and its suitability for the purposes for which it may be required can therefore be all the more readily gauged. Whether or not it was grown in congenial soil may also be gathered from an inspection of the thickness or spareness of these tell-tale rings, the appropriateness of the ground being estimated by the quality and depth from year to year. In all cases the external or youngest layers are the most juicy and least dense, and every carpenter knows the difference between sap-wood and heart-wood.

In this way trees grow, but how the flint of the soil is transferred into their substance, or in what manner that which of itself is incapable of giving nourishment is transformed into wholesome vegetable aliment, is so far, unfortunately, a puzzle alike to the chemist and the botanist. —Illustrated Carpenter.

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