when one of a pair was shot, the other went on feeding as though nothing had happened.

"The thrush (*Turdus erythropleurus*) is very abundant, and as tame as possible. None of my specimens show any mottling, but Capt. Aldrich told me that he saw one with the breast mottled. The bill and feet are as yellow as a cock blackbird's. I heard no *song*, but they often give a 'chick——chick——chick—chick-chick-chick,' quickening time at the finish.

"Parties of twelve to twenty of a species of *Zosterops* were very common. They had just-fledged young ones among them.

"The other birds we obtained were two hawks, an owl, a swift, a heron, a plover, and a sandpiper. Besides these, frigate-birds, gannets, boobies, and boatswain-birds of two kinds were everywhere abundant.

"We obtained three kinds of lizards, and the *Typhlops* which was found before, but no tortoises. We saw a turtle making off down the beach early one morning, but it got into the sea before it could be turned over.

"We saw no frogs, and heard none.

"We found five kinds of land-shells, four of butterflies, a few moths, and some eighteen species of beetles, besides spiders, centipedes, &c. I have one of the hawks alive, which I hope to be able to bring home to England. . . . . "J. J. LISTER."

Accounts have been received from Captain Aldrich, R.N., of H.M. surveying-vessel *Egeria*, of a recent visit to Christmas Island in the Indian Ocean, made in consequence of the interest attaching to the small collection recently brought thence by Captain Maclear, R.N., (see NATURE, vol. xxxvi. p. 12). Mr. J. J. Lister kindly volunteered to act as naturalist, and proceeded from England to Colombo, whence he took a passage in the *Egeria* for the purpose of collecting.

Captain Aldrich states that the highest point of the island was reached at the expense of considerable labour, but without as much difficulty as was anticipated. This point is 1200 feet high, and not, as was before incorrectly stated, 1580 feet.

The island is coral-clad to the very top, the actual summit being a block of coralline limestone, worn and undermined. No rock other than of a calcareous nature was met with in the island, though a diligent search was made, and holes dug where the soil appeared thickest.

Three tiers of cliffs, probably marking sea-levels, intervene between the top of the existing sea cliffs and the summit. Breaches in these cliffs afforded means of scaling them, aided by the numerous aërial roots of the trees with which the island is densely covered.

Between the cliffs the ground rises irregularly, being covered in some places with soil apparently deep, intermixed with fragments of coral. Tangled jungle and high forest grow everywhere. The vertical rise to the summit where ascended takes place in the following manner, as described by Captain Aldrich :—

Coast cliff	30	feet vertical.
Moderate slope	90	,,
First inland cliff	85	,,
Moderate slope	250	,,
Second inland cliff / Slope / Third inland cliff	95	,,
Steep slope of rough ground	650	,,

The total horizontal distance is about 5000 feet.

Christmas Island therefore appears to be a remarkable instance of the complete casing with coral of an island which, from the time that its nucleus first came within the reef-building zone, has been steadily subjected to a movement of upheaval, varied by pauses, during which the cliffs were eroded by the sea. So far as I am aware, no case of similar magnitude has yet been recorded.

The collections now on their way to England are, it is feared, not so varied as was anticipated from the samples of life brought home by the *Flying Fish*.

A considerable number of interesting photographs were obtained by the officers, and accompany Captain Aldrich's report, which will be published.

The *Egeria* has obtained a line of soundings across the hitherto unfathomed area of the southern Indian Ocean, between the Strait of Sunda and Mauritius, but no details have as yet come to hand.

December 17. W. J. L. WHARTON.

TIMBER, AND SOME OF ITS DISEASES.[1]

II.

THE enormous variety presented by the hundreds of different kinds of woods known or used in different countries depends for the most part on such peculiarities as I have referred to above, together with some others which have not as yet been touched upon. Everybody knows something of the multitudinous uses to which timber is put, and a little reflection will show that these uses are dependent upon certain general properties of the timber. Speaking broadly, the chief properties are its weight, hardness, elasticity, cohesion, and power of resisting strains, &c., in various directions, its durability in air and in water, and so forth; moreover, special uses demand special properties of other kinds also, and the colour, closeness of texture, capacity for receiving polish, &c., come into consideration.

Now, there is no doubt that the structure of the wood as formed by the cambium is the chief factor in deciding these technological characters: it is not the only factor, but it is the most important one. Consequently no surprise can be felt that those who are interested in timber have of late years turned their attention to this subject with a view to ascertain as much as possible about this structure, and to see whether it can be controlled or modified, what dangers it is subject to, and how far a classification of timbers can be arrived at. The more the subject is studied, the more interesting and practically important the matter becomes. The results already obtained (though the study is as yet only in its infancy), have thrown brilliant light on several burning questions of physiology—as witness the researches of Sachs, Hartig, Elfving, and Godlewski, on that old puzzle, to account for the ascent of water in tall trees. The study is, moreover, of first importance for the comprehension of the destruction of timber, due to "dry-rot" and the parasites which cause diseases in standing trees, as is shown by the brilliant researches of Prof. R. Hartig on the destruction of timber by Hymenomycetes; and again as yielding trustworthy information as to the value of different kinds of timber in the arts, and enabling us to recognize foreign or new woods of value. In support of this statement it is only necessary to call attention to the "Manual of Indian Timbers," prepared for the Indian Government by Mr. Gamble; or to refer to the beautiful series of wood-sections prepared by Nördlinger.

It is, of course, impossible in an article like the present to do more than touch upon a few of the more interesting points in this connection; but I may shortly summarize ono or two of the more striking of these peculiarities of timbers, if only to show how well worth further investigation the matter is.

Many timbers, from both tropical and temperate climates, exhibit the so-called "annual rings" on the transverse section; but this is not the case with all. Most European timbers, for instance, are clearly composed of such layers; but in some cases the layers ("rings" on the transverse section) are so narrow and

[1] Continued from p. 186.

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numerous that the unaided eye can scarcely distinguish them, or the differences between the spring and autumn wood are so indistinctly marked that they may appear to be absent, or are at least obscure, as in the Olive, Holly, and Orange, for instance. It is in the tropics, however, that timber without annual rings is most common, chiefly because the seasons of growth are not sufficiently separated by periods of rest to cause the

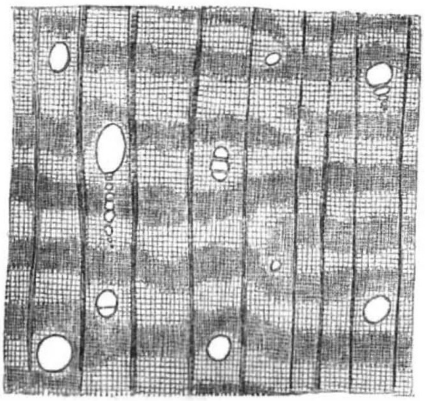

FIG. 7.—Transverse section of the wood of *Pongamia glabra*, Vent., selected to show a type of timber not uncommon in India. No distinct annual rings appear, but the wood is traversed by wavy bands of tissue, which may run into one another or not. The vessels ("pores") are few and scattered, and differ in size; the medullary rays well marked, but not large. To this type—differing in other details—belong many species of figs, acacias, and other Asiatic Leguminoseæ, &c.

formation of sharply-marked zones, corresponding to spring and autumn wood, *e.g.* some Indian Leguminosæ, &c. Zones of tissue of other kinds often occur in such timbers, and have to be understood, since they affect the properties of the wood very differently, *e.g.* some of the Figs.

None of the conifers or dicotyledonous trees, however, are devoid of medullary rays, and distinctive characters

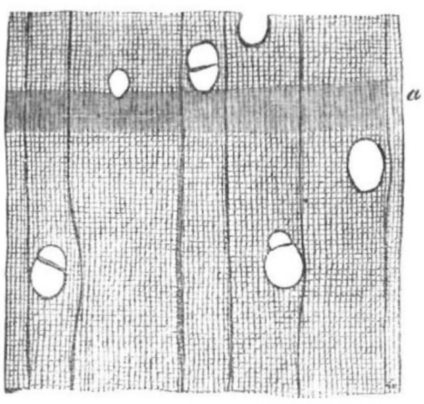

FIG. 8.—Transverse section of wood of *Tamarindus indica*, Linn., selected to show a not uncommon type of Asiatic timber. The annual rings are indistinct, but occasionally indicated by denser tissue (*a*). The vessels are fairly large and few, and scattered much as in Fig. 7, but there are no such broad bands of cells as there.

are based on the breadth and numbers of these: as examples for contrast may be cited the fine rays of the Pines and Firs, and the coarse obvious ones of the Oaks.

Again, the prominence or minuteness, or even (Coniferæ) absence, of vessels in the secondary wood afford characters for classification. The contrast between the extremely small vessels of the Box and the very large ones of some Oaks and the Chestnut, for instance, is too striking to be overlooked. Then, again, in some timbers the vessels are distributed more or less equably throughout the "annual ring," as in the Alder, some Willows and Poplars, &c.; whereas in the Chestnut and others they are especially grouped at the inner side of the annual zone (*i.e.* in the spring wood), and in some cases these

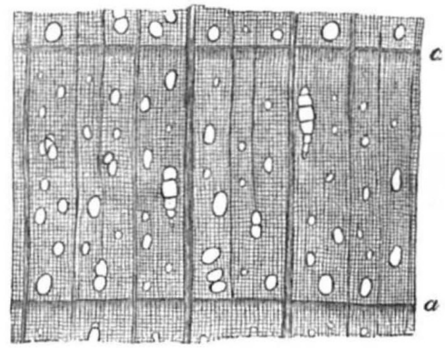

FIG. 9.—Transverse section of the wood of *Acer pseudo-platanus*, selected to show a type of timber common in Europe. The annual rings (*a*) are well-marked and regular. The vessels are small and numerous, and scattered somewhat equally over the whole breadth of the ring. The medullary rays are numerous, some broad, some fine. Many European timbers (beech, hornbeam, lime, &c.) agree with this type, except in details.

groupings are such as to form characteristic figures on the transverse section, as in some Oaks, *Rhamnus*, &c. In the woodcuts (Figs. 7–10) I have given four examples illustrating a few of the chief points here adverted to.

Passing over peculiar appearances due to the distribution of the wood-parenchyma between the vessels, as

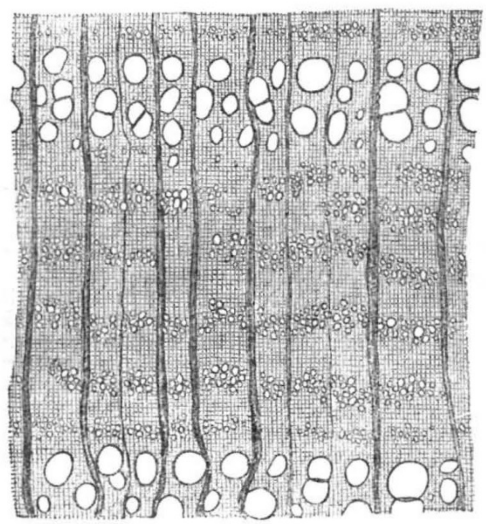

FIG. 10.—Transverse section of wood of the common elm (*Ulmus campestris*), selected as a common type of European timber. The annual rings are very distinct, owing to the large vessels in the spring wood; the vessels formed during the summer and autumn are grouped in bands or zones. The medullary rays are numerous, but not very broad. The oak, ash, chestnut, and others agree in the main with this type, differing chiefly in the *mode of grouping* of the smaller vessels, and in the *breadth* of the medullary rays.

exemplified by the Figs and the Maples, as well as minor but conspicuous features which enable experts to recognize the timber of certain trees almost at a glance, I may now proceed to indicate a few other peculiarities which distinguish different timbers.

The weight of equal volumes of different woods differs

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more than is commonly supposed, and there are certain details to be considered in employing weight as a criterion which have not always been sufficiently kept in mind.

A cubic foot of "seasoned" timber of the Indian tree *Hardwickia binata* weighs about 80 lbs. to 84 lbs., while a cubic foot of *Bombax malabaricum* may weigh less than 20 lbs., and all gradations are possible with various timbers between these or even greater extremes. If we keep in mind the structure of wood, it is evident that the weights of equal volumes of merely seasoned timber will yield only approximate results. For even if the seasoning, weighing, &c., are effected in a constant atmosphere, woods which differ in "porosity" and other properties will differ in the extent to which they absorb moisture from damp air or give it up to dry air.

In our climate, timber which is felled in April or May, generally speaking, contains much more water than if felled in July and August: it is, in fact, no uncommon event to find that about half the weight, or even more, of a piece of recently felled timber is due to the water it contains. If this water is driven off by heat, and the piece of wood thoroughly dried, the latter will be found to weigh so much less, but it will increase in weight gradually as it imbibes moisture again.

Now it happens that the weight of a piece of timber, compared with that of an equal volume of some standard substance—in other words, the specific weight—is of very great importance, because several other properties of wood stand in relation with it, *e.g.* the hardness, durability, value as fuel, tendency to shrink, &c. Fresh-cut timber in very many cases contains on an average about 45 to 50 per cent. of its weight of water, and if "seasoned" in the ordinary way this is reduced to about 15 to 20 per cent.; but the fresh timber also contains air, as may easily be shown by warming one end at the fire or in hot water and watching the bubbles driven out, and the seasoned timber contains less water and more air in proportion, so that we see how many sources of error are possible in the usual weighings of timber. At the same time, many comparative weighings of equal volumes of well-seasoned timber do yield results which are of rough practical use.

The fact is that the so-called "specific weight" of timber, as usually given, is not the specific gravity of the wood-substance, but of that *plus* entangled air and water. It is interesting to note that, although we associate the property of floating with wood, timber deprived of its air will sink rapidly, being about half as heavy again as water, volume for volume.

The point just now, however, is not to discuss these matters in detail, but rather to indicate that, other things equal, the density of a piece of timber will be greater, the more of that closely-packed, thick-walled autumn wood it contains; while the timber will be specifically lighter and contain more air when dry, the greater the proportion of the looser, thin-walled spring wood in its "annual rings." In other words, if we could induce the cambium to form more autumn wood and less spring wood in each annual ring, we could improve the quality of the timber; and, in view of the statement which has been made, to the effect that large quantities of timber of poor quality reach the Continental wood-yards every year, this is obviously an important question, or at any rate may become one. The remainder of this article must be devoted to this question alone, though it should be mentioned that several other questions of scientific and practical importance are connected with it.

The first point to notice is that the cambium-cells, like all other living cells which grow and divide, are sensitive to the action of the environment. If the temperature is too high or too low, their activity is affected and may even be brought to an end; if the supply of oxygen is too small, their life must cease, since they need oxygen for respiration just as do other living cells; if they are deprived of water, they cannot grow—and if they cease to grow they cannot divide, and any shortcomings in the matter of water-supply will have for effect a diminution of activity on the part of the cambium. The same is true of the supply of food-substances: certain mineral salts brought up from the soil through the roots, and certain organic substances (especially proteids and carbo-hydrates) prepared in the leaves, are as necessary to the life of a cambium-cell as they are to the life of other cells in the plant. Now, since the manufacture of these organic substances depends on the exposure of the green leaves to the light, in an atmosphere containing small quantities of carbon-dioxide, and since the quantities manufactured are in direct relation to the area of the leaf-surface—the size and numbers of the leaves—it is obvious that the proper nourishment of the cambium is directly dependent on the development of the crown of foliage in a tree. Again, since the amount of water (and mineral salts dissolved in it) will vary with the larger or smaller area of the rootlets and absorbing root-hairs (other things equal), this also becomes a factor directly affecting our problem. Of the interdependencies of other kinds between these various factors we cannot here speak, since they would carry the argument too far for the space at command; some of them are obvious, but there are correlations of a subtle and complex nature also.

First as to temperature. The dormant condition of the cambium in our European winter is directly dependent on the low temperature: as the sun's rays warm the environment, the cambial cells begin to grow and divide again. The solar heat acts in two ways: it warms the soil and air, and it warms the plant. Wood, however, is a bad conductor of heat, and the trunk of a tree is covered by the thick corky bark, also an extremely bad conductor, and it would probably need the greater part of the early summer to raise the temperature of the cambium sufficiently for activity in the lower parts of a tree by direct solar heat: the small twigs, on the contrary, which are covered by a thin layer of cortex, and epidermis, are no doubt thus warmed fairly rapidly, and their early awakening is to be referred to this cause. The cambium in the trunk, however, is not raised to the requisite temperature until the water passing up through the wood from the roots is sufficiently warm to transmit some of the heat brought with it from the soil to the cells of the cambium. This also is a somewhat slow process, for it takes some time for the sun's rays to raise the temperature of the soil while the days are short and the nights cold. Hartig has shown that the cambium in the lower part of the trunk of a tree may be still dormant three weeks or a month after it has begun to act in the twigs and small branches; and it has also been pointed out that trees standing in open sunny situations begin to renew their growth earlier than trees of the same species growing in shady or crowded plantations, where the moss and leaf-mould, &c., prevent the sun from warming the soil and roots so quickly. These observations have also a direct bearing on the later renewal of cambial activity in trees growing on mountains or in high latitudes. Moreover, though I cannot here open up this interesting subject in detail, these facts have their connection with the dying off of temperate trees in the tropics, as well as with the killing of trees by frost in climates like our own. One important practical point in this connection may be adverted to. Growers of conifers are well aware that certain species cannot be safely grown in this country (or only in favoured spots) because the sun's rays rouse them to activity at a time when spring frosts are still common at night, and their young tissues are destroyed by the frosts. Prof. R. Hartig has pointed out a very instructive case. The larch is an Alpine plant, growing naturally at elevations where the temperature of the soil is not high enough to communicate the necessary stimulus to the cambium until the end of May or June.

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Larches growing in the lowlands, however, are apt to begin their renewed growth in April, and frosted stems are a common result, a point which (as the renowned botanist just referred to also showed) has an important bearing on that vexed question—the "larch-disease."

The supply of oxygen to the cambium is chiefly dependent on the supply of water from the roots, and the aëration of the stem generally. The water begins to ascend only when the soil is warm enough to enable the root-hairs to act, and new ones to be developed, and the supply of mineral salts goes hand in hand with that of water.

Now comes in the question of the sources of the organic substances. There is no doubt that the cambium at first takes its supply of food-materials from the stores which have been laid by, in the medullary rays, &c., at the conclusion of the preceding year; and it is known that special arrangements exist in the wood and cortex to provide for this when the water and oxygen arrive at the seat of activity.

Assuming that all the conditions referred to are favourable, the cambium-cells become filled with water in which the necessary substances are dissolved, and distended (become turgid, or turgescent, as it is technically called) sufficiently for growth. Speaking generally, and with reference chiefly to the trunk of the tree, which yields the timber, the distension of the cells is followed by growth in the direction of a radius of the stem, and division follows in the vertical plane, tangential to the stem. Then the processes already described with reference to Fig. 5 repeat themselves, and the trunk of the tree grows in thickness.

Now it is obvious that the thickening of the mass of timber inside the cylinder of cambium must exert pressure on the cortex and bark—must distend them elastically, in fact—and some ingenious experiments have been made by De Vries and others to show that this pressure has an effect in modifying the radial diameter of the cells and vessels formed by the cambium. Several observers have promulgated or accepted the view that the differences between so-called spring and autumn wood are due to the variations in pressure of the cortex on the cambium, but the view has lately gained ground, based on experimental evidence, that these differences are matters of nutrition, and a recent investigator has declared that the thick-walled elements and small sparse vessels characteristic of autumn wood can be produced, so to speak, at will, by altering the conditions of nutrition.

It is authoritatively stated that the pines of the cold northern countries are preferred for ships' masts in Europe, and that the wood-cutters and turners of Germany prize especially the timber of firs grown at high elevations in the Bavarian Alps. Now the most striking peculiarity of the timbers referred to is the even quality of the wood throughout: the annual rings are close and show less of the sharp contrasts between thin-walled spring wood and thick-walled autumn wood, and Hartig suggested that this is due to the conditions of their nutrition, and in the following way. The trees at high elevations have their cambium lying dormant for a longer period, and the thickening process does not begin in the lower parts of the trunk until the days are rapidly lengthening and the sun's rays gaining more and more power: the consequence is that the spring is already drawing to a close when the cambium-cells begin to grow and divide, and hence they perform their functions vigorously from the first.

One of the most interesting experiments in this connection came under my observation this summer, owing to the kindness of Prof. Hartig. There is a plantation of larches at Freising near Münich, with young beeches growing under the shade of the larches. The latter are seventy years old, and are excellent trees in every way. About twenty years ago these larches were deteriorating seriously, and were subsequently "under-planted" with beech, as foresters say—*i.e.* beech-plants were introduced under the shade of the larches. The recovery of the latter is remarkable, and dates from the period when the under-planting was made.

The explanation is based on the observation that the fallen beech-leaves keep the soil covered, and protect it from being warmed too early in the spring by the heat of the sun's rays. This delays the spring growth of the larches: their cambium is not awakened into renewed activity until three weeks or a month later than was previously the case, and hence they are not severely tried by the spring frosts, and the cambium is vigorously and continuously active from the first.

But this is not all. The timber is much improved: the annual rings contain a smaller proportion of soft, light spring wood, and more of the desirable summer and autumn wood consisting of closely-packed, thick-walled elements. The explanation of this is that the spring growth is delayed until the weather and soil are warmer, and the young leaves in full activity; whence the cambium is better nourished from the first, and forms better tracheides throughout its whole active period. Such a result in itself is sufficient to repay the investigations of the botanist into the conditions which rule the formation of timber, but this is by no means the only outcome of researches such as those carried on so assiduously by Prof. Hartig in Münich, and by other vegetable physiologists.

It is easy to understand that the toughness, elasticity, and such like qualities of a piece of timber, depend on the character of the tracheides, fibres, &c., of which it is chiefly composed. Investigations are showing that the length of such fibres differs in different parts of the tree. Sanio has already demonstrated that in the Scotch pine, for instance, the tracheides differ in length at different heights in the same trunk, becoming longer as we ascend, and also are longer in the outer annual rings than in the inner ones as the tree grows older, up to a certain period; and this is in accordance with other statements to the general effect that for many years the wood improves, and that better wood is found at the base of the trunk.

However, it is impossible to pursue these subjects in all their details: my object is served by showing how well worthy of the necessary scientific study is timber even to those who are only concerned with it in its usual conditions, and within those limits of variation in structure and function which constitute health. The importance of the subject in connection with the modern development of biology along the grand road of comparative physiology, does not need insisting upon here. It will be the object of further articles to show how it is, if possible, still more important and interesting to know the structure and functions of healthy timber, before the practical man can understand the diseases to which timber is subject. At the same time it must be clearly borne in mind that these are but sketches of the subject; for it is as true of trees and their diseases as it is of men and human diseases, if you would be trainers and doctors you must know thoroughly the structures and peculiarities of the beings which are to be under your care.

H. MARSHALL WARD.

(*To be continued.*)

NOTES.

THE collections of natural history lately forwarded to the British Museum by Dr. Emin Pasha, from Central Africa, will be described at the meeting of the Zoological Society on January 17. The specimens have been determined by various experts in the different branches of natural history to which they belong. Mr. Oldfield Thomas has prepared a paper on the mammals, amongst which are examples of a remarkable

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