# DRY ROT IN TIMBER

W. H. BIDLAKE, M.A.

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# DRY ROT IN TIMBER,

BY

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R.I.B.A., Silver Medallist and Pugin Student.

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Auerbach p 17

## PREFACE.

THE substance of this pamphlet was read as a paper before the London Architectural Association last February. I did not originally intend to publish it; but having not infrequently received letters from those who had been brought face to face with a problem of Dry Rot, and having learned that reports of the lecture had been published in Paris and America, I was encouraged to believe that it had proved useful, and might be more so, if published with illustrations in a compact form.

W. H. B.

February, 1889.
37, Waterloo Street, Birmingham.

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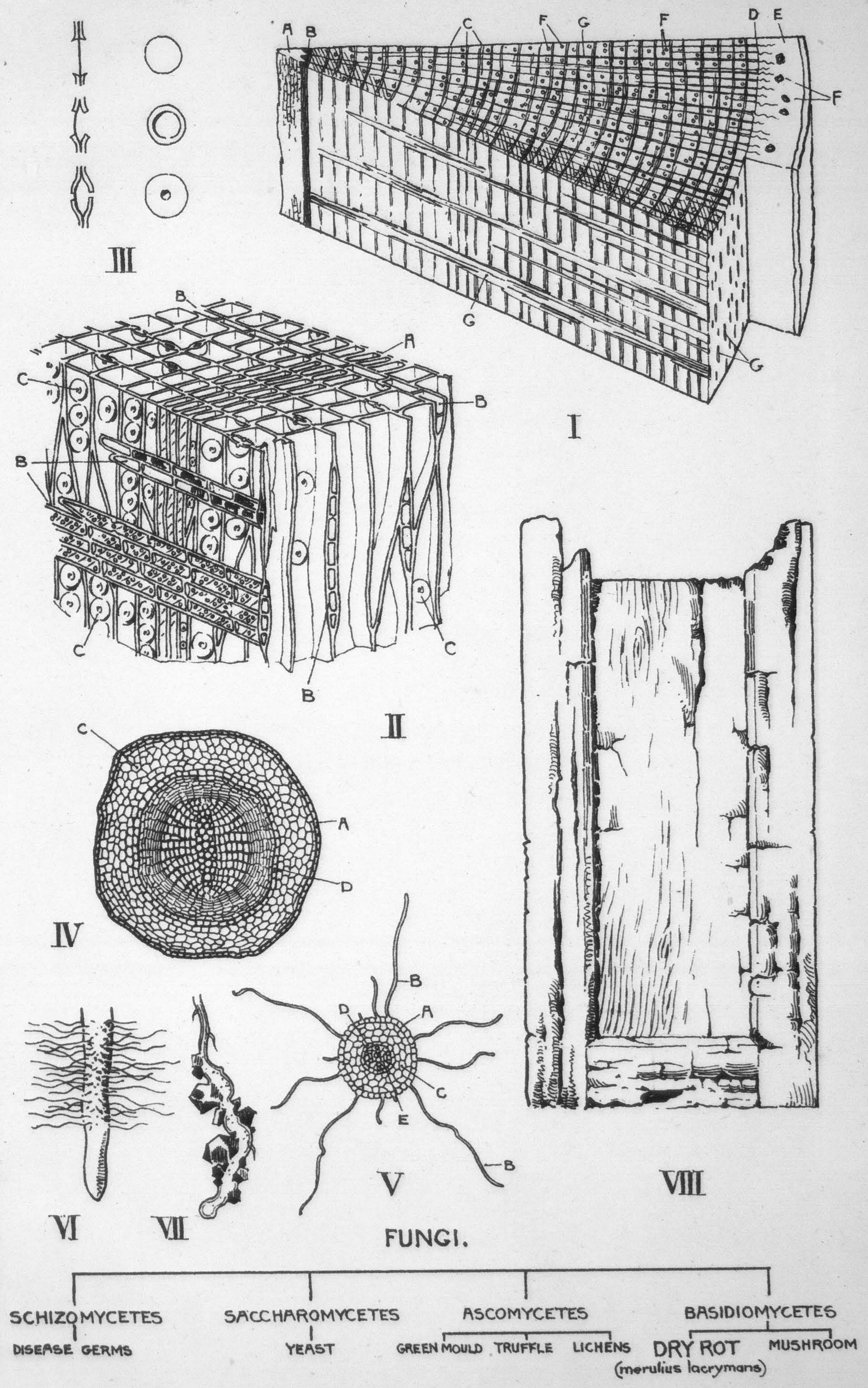

W.H.B delt.

J. Akerman Photo-lith London

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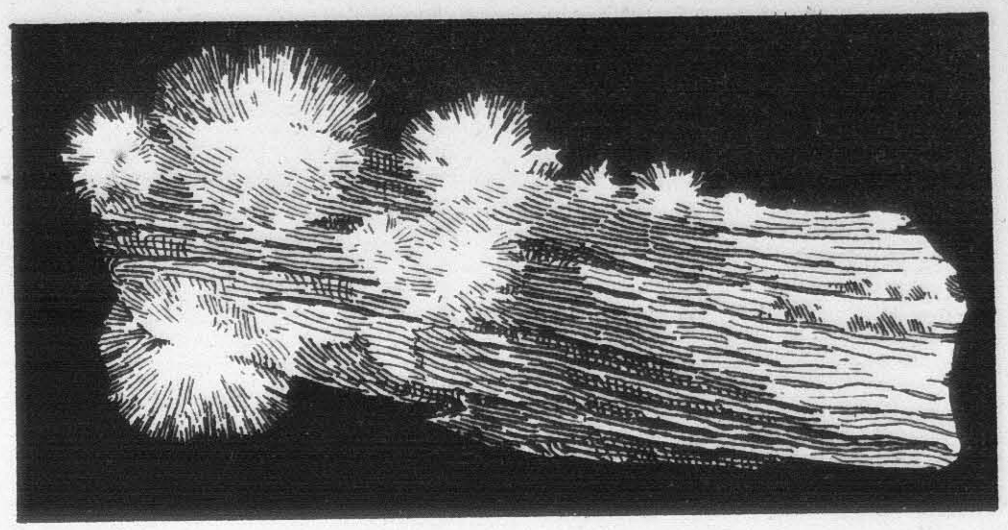

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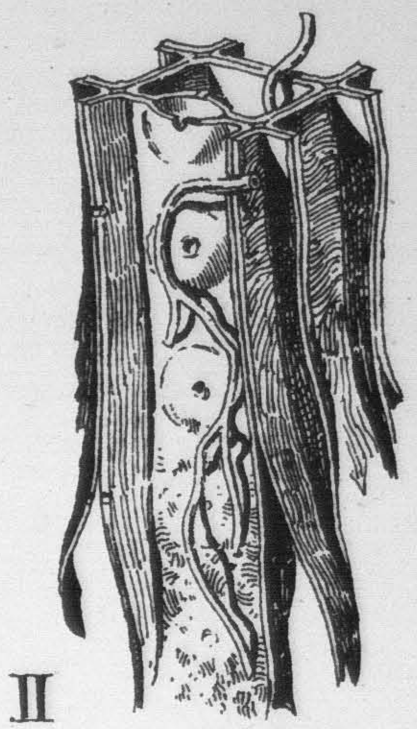

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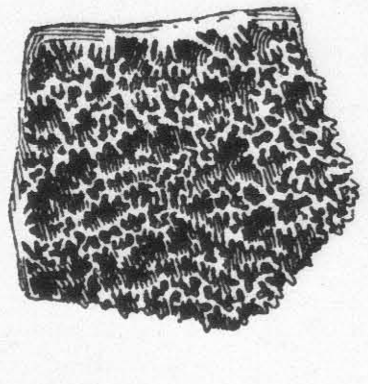

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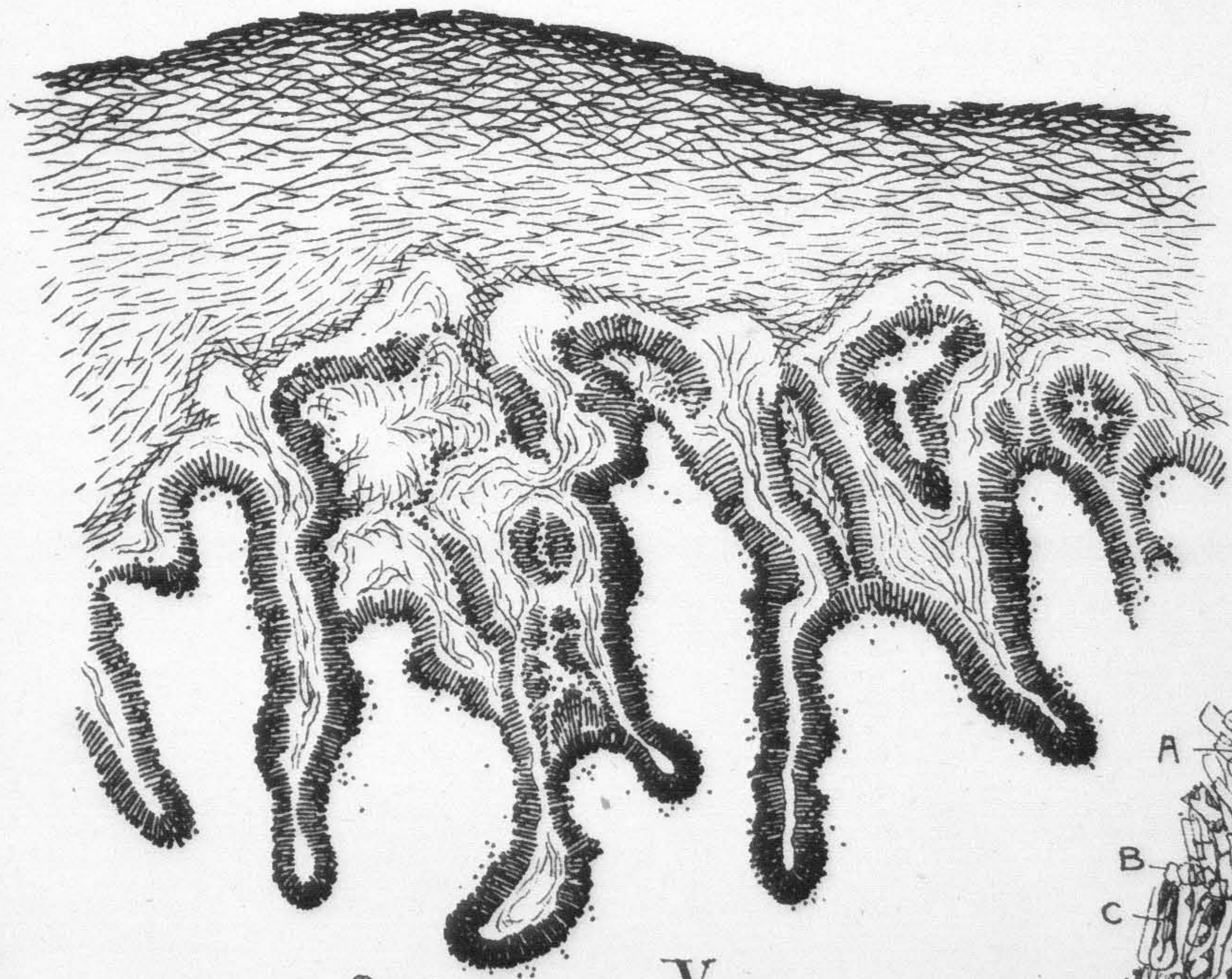

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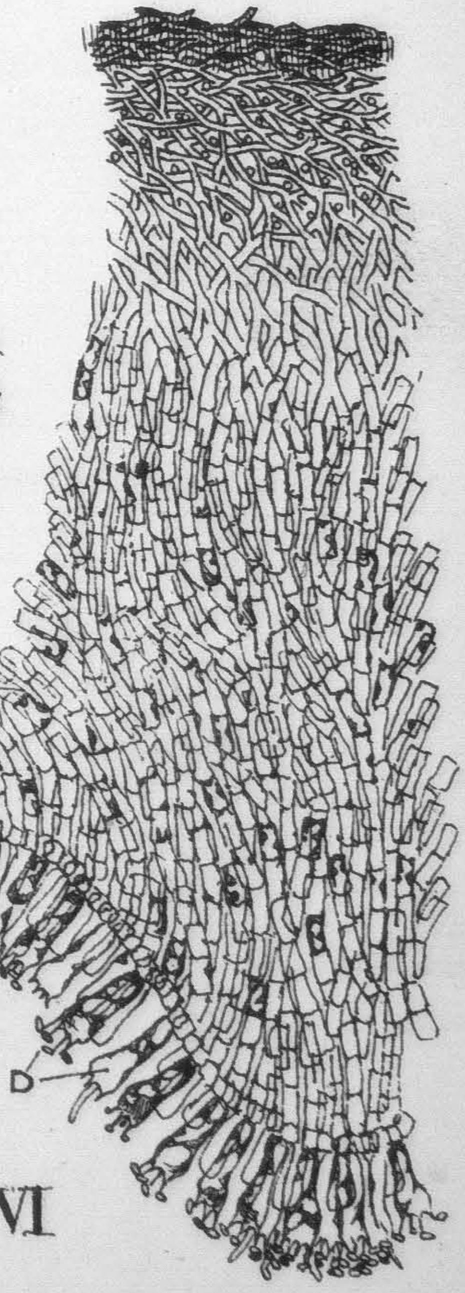

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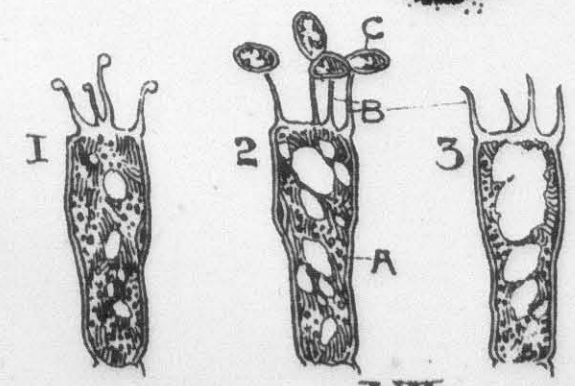

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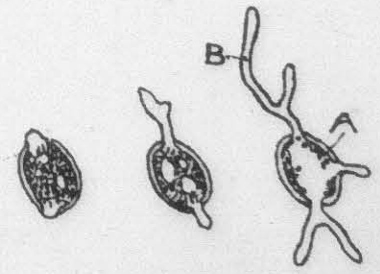

VIII

W.H.B delt.

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# DRY ROT.

THE subject of my paper as announced in the Brown Book is "A Botanical Contribution to Architecture." This is a vague title and encloses a wide field. My particular subject, however, is "Dry Rot," as the diagrams on the screen will probably have revealed. I must, however, narrow the limits of my subject still further, for "dry rot" is frequently induced in different woods by different species of fungi, and even the timber of the coniferæ may be attacked by different species, although their effect on the wood is practically the same. I propose, then, to consider only the commonest, most destructive, and best known of the dry rot fungi, *Merulius lachrymans*, its life history, and its effect on pine wood.

Whereas most fungi are to be found in the damp surroundings of the forest, *Merulius*, being of a more genteel nature, prefers the wrought timber work of a house, and has rarely, if ever, been found in a wild state.

When commencing to grow this fungus last autumn, with the object of observing its habits and testing the susceptibility of wood of various degrees of seasoning to its attacks, I found I could obtain very little satisfactory information on the subject from books or pamphlets, but within the last few weeks a series of excellent articles has appeared in *Nature* on the

"Diseases of Timber," from the pen of Professor Marshall Ward, and I wish to express at the outset my indebtedness to them. I learn that they are to be extended and published in a book form by Messrs. Macmillan and Co. within a short time, and I believe the work will prove invaluable to architects as a book of reference.

We cannot study the diseased state of an organ intelligently without knowing its healthy state, and it will be necessary, therefore, to consider the structure of sound pine wood, and, to some extent, the physiological functions of its parts, before discussing the diseased state induced by *Merulius*.

Let us suppose we have the opportunity of examining a piece of pine trunk (Plate I., Fig. I.). We shall observe:—I. The central axis of pith composed of loosely-packed thin-walled cells, and surrounded by groups of tubular vessels having spirally thickened walls, forming more or less of a cylinder, called the *medullary sheath*. II. Outside this comes the great mass of the wood, which is marked on the transverse section by two systems of lines, the concentric lines showing the *annual rings* and the radial lines the *medullary rays*. Both produce lines of weakness, and frequently give rise to cracks,—"cup-shakes" resulting from the former, "star-shakes" from the latter. All the medullary rays appear to start from the periphery of the wood,—some extending right through to the pith and others to various distances. Amongst the wood it will also be noticed that here and there the cells have separated so as to form *resin passages*. III. Outside the wood, and separated from it by the series of wet succulent cells of the *cambium*, comes the bark. This in its inner portion is traversed by medullary rays, and includes the *sieve-tubes*, which are long tubular cells, the one separated from that below by a perforated plate or sieve. The outer portion includes more spherical-shaped cells containing nutrient substances. Here and there is to be seen a large resin passage.

The whole is invested with layers of impervious cork, which keeps the tree from the weather.

If then we examine from the pith outwards, we shall pass ring after ring of annual growth, and while we shall not lose the old, we shall continually find new medullary rays starting. As we get near the margin of the wood its cells will become more delicate, until we arrive at that line of succulent cells which separates the wood from the bark—the line of weakness through which the bark tears off. These cells form the *cambium* or growing issue of the tree; they are delicate thin-walled, filled with granular protoplasm, bathed with fluid, and divided tangentially, giving rise to new wood cells on the one hand and, to a much less extent, new bark cells on the other.

I have used the term "protoplasm." By it is understood that transparent, semi-fluid, glairy substance which is always present in living cells, whether animal or vegetable, and which has been called the "physical basis of life." For life apart from it is unknown, and by it all tissues, howsoever differentiated, have been formed. It is a highly complex substance, and consists chemically of carbon, hydrogen, oxygen, nitrogen, sulphur, and perhaps a little phosphorous.

When newly formed from the cambium the wood cells contain protoplasm and nutrient substances, and their walls, which are thin, are composed of cellulose. The protoplasm employs itself with thickening the cell wall by adding layers of cellulose, in which process not only are the nutrient substances used up, but the protoplasm is itself eventually absorbed.

This thickening does not take place regularly over the whole of the cell, for, chiefly on its radial walls, rows of circular areas remain thin, and the cell wall is prolonged inwards from their margins so as to surround the depression thus formed. As an exactly similar operation is in process at the same spot in the next cell, a structure results which one may compare to two thick watch-glasses, each pierced by a hole in the centre, placed face to face, and the thin persistent membrane between adhering to the inner surface of one of the glasses. The whole structure is called a "bordered pit," and when seen in front elevation it presents the appearance of two concentric circles. (See Figs. II. and III.) It plays an important part in the diffusion of water.

When the operation of thickening the cell wall is complete, and the cell contents used up, an important change takes place: the cellulose becomes converted into lignin. This is not a definite chemical compound, but includes several substances, of which lignose is an important one. The cell walls are now said to be lignified; they now form true wood. This change renders them harder, more elastic, less absorbent, but at the same time easily traversed by water. The centre line between one thickened cell wall and another undergoes a still further change, and is called the "middle lamella."

We must think of pine wood, then, as made up of long tubular cells (see Plate I., Fig. II.), nearly square on plan, with bluntly tapering ends, whose radial walls are studded with bordered pits. Such cells are called "*tracheïdes.*"

Those *tracheïdes*, which form the darker-coloured and more compact wood of the annual ring, have very short thick radial walls, which have small pits, or are simply striated. The tangential walls are thus brought very close together.

The medullary rays have cells disposed like the stretching courses of very long bricks, and from one to six courses deep, and are lenticular in cross section. The cells of some rays have pits, and spiral markings, others are plain. These latter are storage cells, and in them food material is laid during summer, when the leaves are active, to be used the next spring.

It will now be necessary to glance at the structure of the root, or, rather, one of the rootlets (Plate I., Fig. IV. is a section through a rootlet; Fig. V. shows its end, with root-hairs; and Fig. VI. shows a root-hair in contact with particles of soil). Here the central axis is formed by the woody vessels invested with a membrane (*endodermis*), and is surrounded by tissue (*parenchyma*) somewhat resembling pith in its structure, whose cells are lined with protoplasm and have cellulose walls. The whole is invested by a membrane, one cell thick,—the *epidermis.* Many of these epidermis cells grow out into long closed tubes, called *root hairs*, so that the end of a rootlet resembles in appearance a diminutive brush, such as is used for cleaning glass tubes. These root hairs are in most intimate contact with the particles of soil, and absorb water from the thin film with which the particles are coated,—not the water which fills the interstices of the soil. This absorption of water through the cell wall is induced by the presence of organic acids within the cell, and is so great that not only does the cell become distended with water, but it often takes up more than it can hold, so that the water exudes again. This is called the *osmotic* property of cells, and is of immense importance to plant life : in fact, plant life may be said to be dependent upon it. The cells contiguous to the root hairs now absorb the water from them in the same way as, and from the same cause that they had absorbed it from the soil. Water is thus passed on from cell to cell until all the cells become distended with it, and at length the hydrostatic pressure becomes so great that the water is filtered through the walls into the woody vessels in the centre of the rootlet. The total sum of the pressures exerted by all the rootlets is called "*root-pressure*," and may be so great that water is forced up the trunk of the tree to considerable height.

Turning now to the leaves, we shall find that their constituent cells are kept tense with water, which, however, they are continually losing by evaporation through the "breathing" pores or "*stomata*." But while they are losing water by evaporation, they are at the same time, in virtue of their osmotic properties, taking it from the neighbouring cells, and these in turn are taking it from others, and so on, till at length the vessels are reached and their water drawn from them. The whole process is called "Transpiration."

Here, then, we have the roots forcing up water from below, and the leaves drawing up water from above. By what channel does it flow ? It flows in the outer rings of the wood, which are in consequence called "sap wood," or alburnum. Yet if the trunk be cut across, except at certain times, more especially in the spring, the vessels will be found to be empty, and that notwithstanding the fact that the leaves may have been at the time most actively transpiring. The fact is, the water passes upward in the substance of the lignified cell walls of the sap wood. (It has already been remarked that lignin is very readily traversed by water.) I made a reservation a short time ago : I said that the wood vessels were empty *except in spring.* Now, in spring the ground soon gets warmed as the sun gains power, and, in consequence, the roots get stirred to activity, and water is filtered into and forced up the vessels. The new leaves are, however, not yet formed, and the old ones not fully awake, and so there is little or no transpiration. The water is forced up by root-pressure alone, and fills the cavities of the vessels. The sap is now said to be rising, and if the tree be cut, water exudes from the lower portion in connection with the roots, and it is said to "bleed." Spring is in consequence the worst time for felling trees. This, however, is not all, for the ascent of the warmed water in the wood cells near the cambium awakens those of the later into activity. They begin to divide and form wood cells ; but as the stock of nutrient material stored up in the medullary rays is but scant, and the leaves have not yet begun to send down their contributions, the wood cells formed are necessarily large and thin walled.

As summer comes on the leaves become active, the salts dissolved in the water absorbed by the roots are appropriated, carbonic acid (carbon dioxide) is absorbed from the air, and starch is elaborated in the cells. This, after being converted into a soluble form,—called "elaborated sap"—is handed from cell to cell by osmotic process till it reaches the growing part where the material is required. There is no specialised vehicle for the elaborated sap; it goes where it is wanted, and nowhere else; for only in the direction of those parts where it is being used up is the equilibrium between cell and cell being constantly disturbed, and a current set up in consequence. In this way the sap reaches the cambium, which, being now well supplied with material, manufactures cells of a better quality with good thick walls, so that in the autumn wood the thickness of the walls bears a very considerable ratio to the cavity of the cells. The weather now gets cold, and the cambium becomes dormant until it is awakened in the spring to again manufacture large cells with insufficient material. There is thus a sudden transition from the dense autumn wood to the porous spring wood, and this gives rise to the appearance of the annual rings. This intermittent food supply is, however, not the only cause of the difference between autumn and spring wood, for toward the autumn a very considerable transverse tension is set up owing to the increase in the diameter of the trunk by the activity of the cambium, and this finds expression in the small compact cells that are then formed, as also in the peripherally-stretched cells of the cortex. During winter the cortical tissue becomes dry and cracks, so that in spring the transverse tension is relieved and the new cells are large.

Having now considered the structure and growth of the timber, let us suppose it felled, shipped, stacked, sawn up, and built into a floor, on the ground storey, being quite sound and having escaped the attacks of various fungi and other mischances.

We may, perhaps, now consider it secure. No! A fungus, not of wild forest life, but of domesticated habits, attacks it. *Merulius lachrymans* steals upon it in the dark stagnant air and dooms it to rottenness and decay.

Let us suppose that a single spore of about 1-3,000th of an inch in diameter has found its way to the under-surface of one of the joists, either by this having previously been placed near infected wood, or from being cut by a saw which had been used upon infected wood, or, perhaps, the spore had floated thither in the air. What will happen? That depends largely on the architect and builder.

Every organism to live and thrive must have a congenial environment, and the *Merulius* spore requires darkness and a warm damp stagnant air. This is not, however, sufficient. For a long time the spores could not be induced to germinate artificially until it was discovered a few years ago by Professor Hartig (to whom much of our knowledge of *Merulius* is due), that the presence of an alkali, such as ammonia, is a necessary condition. This frequently rises from the soil when it has not been properly prepared and from bad mortar or defective drains.

The spore lodged on the damp timber now begins to germinate (Plate II., Fig. VIII). One or more protuberances appear on its surface, and these elongate into minute closed tubes or *hyphæ*, the spore meantime becoming exhausted of its contents. From the tips of the hyphæ a solvent is secreted which attacks the lignin and enables the filaments to pierce the cell wall and enter the wood, which soon exhibits a greenish grey soft patch (Plate II., Fig. II.) The hyphæ now divide and ramify, attacking first the nutrient substances stored in the cells of the medullary rays, whence they obtain the nitrogen, potassium and phosphorus necessary for their more vigorous growth. Here and there a white mould breaks out from the joists in rounded patches, looking like white swan's-down or cotton wool, but whose filaments seem to radiate from a number of centres on the surface of the wood (Plate II., Fig. I.) This outgrowth becomes more compact till it forms a dense felt of interwoven hyphæ of a slate or brown colour, which creeps along the surface of the joists and completely encases them, while thick strands of it run in the angles between the boarding and the joists or hang in festoons from one joist to another. In a very bad case which I inspected last November at Tipton Parish Church, in Staffordshire, the joists presented a most remarkable appearance, in all directions appearing as if padded with white cotton wool about 1in. deep, with strands of the same hanging as pendants or in festoons. This is the vegetative part of the fungus and is called the *mycelium*. It corresponds to the "spawn" of the mushroom.

Sometimes, however, the hyphæ instead of forming a matted felt, collect into strings and fibres, giving rise to a delicate black network resembling sprays of seaweed.

Where this outgrowth is taking place on the surface of the wood, the delicate filaments, or hyphæ, are piercing the cell walls, extending along the tracheïdes, and permeating the wood in all directions. The mineral substances are appropriated, and the lignose ($C_{18}H_{26}O_{11}$) of the cell walls, which is more complex in its chemical constitution, and which contains a larger amount of carbon relatively to oxygen than cellulose ($C_6H_{10}O_5$), is converted again into cellulose, which absorbs water and swells up, and then is itself absorbed or broken up into simpler substances by the fungus. The middle lamella of the cells is, moreover, dissolved, and the cells become dissociated.

Outward signs betray the havoc that is going on within. The wood at first becomes discoloured, having a dull sepia hue, with here and there a streak of a yellow-brown colour. It then swells, as the cell walls become converted into cellulose and absorb water; then shrinks as the cellulose is further broken up, and water is absorbed by the fungus or evaporates from the surface, so that long fissures arise, first in the direction of the wood fibres, and then across them, and the wood presents the appearance of having been charred. It also becomes much lighter, gives a dead sound when tapped, and, if damp, is quite soft, and can easily be pierced by a penknife; or, if dry, crumbles away to a light brown powder; moreover, the air in the vicinity has an unpleasant musty smell. It is needless to say that the wood loses all its strength, and may sometimes give rise to sudden and serious accidents. I heard of a case that occurred in Brook-street, where the occupants of a room were disagreeably surprised to find the floor falling in.

It will be seen how necessary moisture is to the well-being of the fungus by the fact that half its weight consists of water. Indeed, so susceptible is it to drought that it soon withers in dry air, and the delicate growth on an infected chip withered after an exposure of a few minutes. The mycelium condenses moisture from the air, and the wood when in a decayed state readily condenses and absorbs it. It is taken up by the hyphæ by virtue of their osmotic action, which is usually so great as to cause water to exude again from the mycelium in minute drops. The mycelium may extend over brickwork, and absorb moisture from it, or it may even penetrate the soil, and ramify in it, and transport moisture to parts growing in dry situations.

This power of condensing and transporting moisture enables the mycelium to spread over substances, such as plaster, iron and glass, which afford it neither moisture nor nourishment, and even to penetrate brick walls.

At Tipton Church a bench-end was completely rotten (Plate I., Fig. VIII.), although the air in the church was comparatively dry, and there was no outward sign of fungus, yet the substance of the wood was evidently permeated by hyphæ, for I broke a piece off, and, having placed it in favourable conditions, found it soon develop an external mycelial growth. It seems probable that these hyphæ were continuous with and obtained moisture from those beneath the floor. Paint may thus secure the exterior of timber, but does not necessarily insure immunity from disease of the interior. Nay, it may even render it more susceptible if the wood was not previously dry and well seasoned, for it imprisons the moisture. I have a piece of grained and varnished skirting which, except for being a little warped, appears quite sound in front, yet the whole of the back has been destroyed by dry-rot fungus allied to that which we are considering (*Polyporus vaporarius*, which causes the red decayed patches in deal called "red rot").

I said that nitrogenous substances formed a necessary part of the food of the fungus (for nitrogen is one of the constituent elements of protoplasm), and that the only important source of such was the medullary rays. Now, it has been observed that the fungus economises these introgenous substances by passing the protoplasmic contents of the older hyphæ on to the younger growing ones.

By virtue of these habits, viz., of drawing moisture from a distance and passing on the cell contents, the fungus can creep across brickwork and attack fresh wood.

We saw, when considering the structure of pine, that the newer wood cells still contained some protoplasm and nutrient matter, and also that the outer rings of wood or alburnum formed the vehicle of the ascending sap. It is evident, therefore, that if a builder has used this green wood, or unseasoned sapwood, he has provided the very substance to encourage the most rapid and vigorous growth of *Merulius*.

Under favourable conditions the dense felted *mycelium* which extends along the under-side of the timber assumes a more definite outline, and along its margins, which often curve slightly downwards, the surface becomes pitted and corrugated, resembling that of spongy india-rubber, but with the walls of the depressions zigzag and serrated (Plate II., Fig. IV.) It now assumes a warm brown colour, and from it are distilled, in consequence of the osmotic activity of its cells, clear drops of water, so that it glistens as if covered with dew.

This is the fructification of the fungus and the pendent tears have given it its specific name (Plate II., Fig. III.)

*Merulius lachrymans* is allied to the mushroom (as shown in the table, on Plate I.), which gives several of the orders of fungi, with their best-known representatives), the *mycelium* corresponds with the mushroom "spawn" and the fructification with the mushroom itself, the zigzag corrugated ridges being the analogue of the mushroom "gills."

Let us now examine the fructification of *Merulius* more in detail (Plate II., Figs. V. and VI.)

The upper surface next the beam is of a stiff corky nature, and composed of interwoven thick walled hyphæ. These in their downward course become more delicate in texture, and are grouped together in bundles *(trama)* forming the irregularities of surface, which we have observed; the cells at the same time become shorter and more spherical, so as to form a more or less distinct limiting layer, the *sub-hymenial layer* which follows all the irregularities of contour. Over this layer numbers of elongated cells, closely packed together, are arranged like velvet pile. These cells are called *basidia*, and in the young state have a simple club-shaped outline. Soon however, from the top of each *basidium* four little horns grow out, which in time develope little knobs at their extremities (Plate II., Fig. VII.) Each little knob increases in size, invests itself with a brown-coloured cell wall, and presents the appearance of a full-grown spore supported on a very delicate stalk *(sterigma)*. Each *basidium* thus produces four spores, borne at the tips of very delicate stalks, and in so doing exhausts itself of the granular protoplasmic substances with which it was at first filled. The spores when ripe are so delicately attached that they easily drop off. Some of the cells of this outer layer (the *hymenium*) however, take a somewhat different shape; they are sterile, and do not produce spores; they are called *paraphyses*. The meaning of the honeycombed surface of the fructification is now

evident: it is to increase the spore-bearing surface. This I conclude, from a very rough calculation, it does about six times. Now, a spore is slightly larger than the red corpuscle of blood, and as this is about 1-3,500th of an inch in diameter, we may suppose each spore is about 1-3,000th of an inch. About nine million spores could therefore be placed within the area of a square inch. If we suppose that on the fructification the spores are placed so far apart that there are only three millions to the square inch, and suppose further that the fructification occupies 6 square inches, which, multiplied by 6 to allow for the honeycombed surface, gives an area of 36 square inches, we should find as a result of our calculation, that about one hundred millions of spores would be produced by a single fructification, and in a bad case of dry-rot there may be many such.

Having now traced the life history of the fungus I should like before closing to make a few practical deductions.

First, with regard to the state of timber used in building. A tree should not be felled before it has arrived at maturity, for it has too large a proportion of sap wood to heart wood; and the season for felling should be that during which the growing and cell-dividing process is dormant, and there is no sap rising through wood cells.

Vitruvius says that felling should take place from early autumn to end of winter, and adds that the tree should be cut to the pith so as to allow the escape of the sap. By Statute of James I. people were prevented from felling trees from April 1st to June 30th, and in France a royal decree in 1669 prescribed the time for felling to be October 1st to April 15th. Napoleon I.

also, in an order issued to the Commissioners of Forests, directed that naval timber should only be felled from November 1st to March 15th.

The wood should afterwards be cut up and slowly but thoroughly seasoned. This is effected by completely immersing in water, steaming or boiling, by which the protoplasmic and nutrient substances are dissolved from the cells. It must then be stacked on end in a well-ventilated shed, whose floor is composed of forge ashes or concrete. Irregular or too rapid drying, or direct sun warmth, causes the wood to split, and gives the fungus ready access to its interior. Of course the use of "green wood" is out of the question. As the resin and tannin (a preparatory stage in the formation of resin) afford food material for the fungus, pitch-pine cannot be considered to be rendered more, but rather less durable by the large amount it contains.

Wood must not only be dry, but be kept dry. This is impossible if the air of the chamber in which it is built is damp, as it condenses and absorbs moisture. To secure dryness, therefore, moisture must be prevented from rising from the soil by a layer of asphalte or concrete; from rising up the walls from the foundations by a damp-proof course; from soaking through the walls by building an air-drain, so that no earth is allowed to be in contact with them above the damp-proof course, unless asphalted outside or built hollow; and lastly by securing thorough ventilation, so that there is no corner where the air can stagnate. All vegetable soil must be removed from the site, for ammoniacal exhalations assist the germination of spores; the drains must be sound, and the mortar made of clean sand.

Salt sea sand should not be used, as it attracts moisture. The house should be well dried before the floors are laid, and kept thoroughly well ventilated. I may here point out the fallacy of burning gas for purposes of drying, for, inasmuch as water is one of the products of combustion, it has quite an opposite tendency.

Any substance or device which imprisons moisture within wood, or prevents free evaporation from its surface, or maintains a damp atmosphere in its neighbourhood, will be almost sure to develope dry rot. It will be wise to assume that the spores are there, and are only waiting for a congenial environment to germinate.

Damp or ill-seasoned wood, therefore, should not be covered with paint or tar; nor wood partitions with wire netting and plaster of Paris. Ordinary plaster however seems sufficiently porous.

Linoleum or kamptulicon on floors is also objectionable, and, indeed, whenever a floor has been washed and scrubbed it should be thoroughly dried before any covering whatever is laid down.

The dark stagnant air in cellars and under the boarded floors of the ground storey is very congenial to fungus growth, and it is a fallacy, very prevalent with architects and builders, that the insertion of air bricks in the wall, below the floor level, insures ventilation. A current of air is not at all a necessary consequence; indeed I have heard of a case in which the fungus was found growing within the air brick. In order to induce a current there must be difference of density between the inside and outside air. It would be well, therefore, to carry up an air flue from the under-floor space along with the smoke flue of the room above. The air bricks should be so placed that there are no corners of stagnant air, and they must not be too near the outside ground level or they will become choked with dirt. They are often inefficient through rust and are not infrequently closed by ignorant people.

Church floors are very susceptible to dry rot, owing to the proximity of the heating apparatus. Here the conditions for fungus growth are often completely fulfilled: warmth, dampness, stagnation and darkness. The amount of water that air will absorb before it becomes saturated increases with the temperature: When the heating apparatus is used on Sunday, the warm air absorbs moisture from every available source, and when the temperature falls again on Monday, water is condensed on the underside of the timbers. Moreover the hot water pipes sometimes leak.

If chips of wood have been left by the carpenters lying about under the floor, they are almost sure to be infected, and are frequently the origin of an attack of dry rot, for not only can the fungus be traced to them, but is found growing most luxuriantly on them. So important is it to take precaution in this matter that it would be well if architects insisted in their specifications on every chip being cleared away below boarded floors. Even when the ground has been covered with concrete, the precaution is necessary, for the chips may become infected before the concrete is dry, and the latter is frequently fractured by the settlement of the walls.

Wooden wine bins and packing cases are, in like manner, often the source of the dry rot fungus, which after infesting the cellars spreads to other parts of the house.

This might be prevented by the use of the terra-cotta honeycomb bins, introduced by Messrs. King and Smith.

Larch joists seem to be more durable in damp air than those of fir or pine, and on the ground storey, a floor laid folding is better than one ploughed and tongued.

In churches wood block flooring is best, but the wood should be laid on coal tar, or coal-tar concrete, and not directly on cement concrete. Timber of large scantling, while appearing perfectly sound, is sometimes quite rotten internally, and strings of mycelium permeate the core. It is wise, therefore, to have all large timber sawn, reversed and bolted, care being taken to insert slips of wood between the pieces so as to allow an air space. As a further precaution, the inside face of each piece might be painted with corrosive sublimate dissolved in methyl alcohol.

Timber, from the nature of its structure, perspires most readily in transverse section, in which the ends of its tubular fibres have been cut across. The ends of beams and joists should, therefore, always be left free, and, if built into the wall, there should be a clear air space surrounding them, which may be lined with asphalte if necessary. They should on no account be bedded in mortar, for the moisture of the mortar is absorbed by capillary attraction into the beam, and is unable to evaporate; moreover, quicklime, unless kept quite dry, has an injurious effect on wood, and it is always present to some extent in fresh mortar.

I have said that stagnant air is a necessary condition for the growth of the fungus. The statement requires modifying. Air in the vicinity of a damp beam, will absorb moisture till it is saturated, the quantity absorbed depending on the temperature of the air.

If the air is stagnant no further absorption will take place: but if the air is in movement, that which has become moisture-laden will be replaced by a fresh volume, drier, and ready in its turn to absorb water, and the beam will in time become quite dry. Now, suppose the current as rapid, but the incoming air saturated or nearly so: evidently, the result will be the same as if the air were quite stagnant. The beam will remain just as damp, in spite of the "ventilation," and the fungus will grow just as vigorously, though perhaps with a less evident snowy exterior. These conditions are not frequently satisfied, as the incoming air is usually drier, but the consideration of them is not to be ignored. I have known the upper floors and even the roof to have been attacked by dry-rot owing to the water from defective gutters and spouts soaking through the brickwork; for though evaporation was more or less active, there was a constant supply of fresh moisture.

In damp and exposed situations the walls should have a vertical bond of hygenic rock composition, or be built hollow. In the latter case, the beams and joists should terminate in the hollow space.

Pugging sometimes causes decay in floors, for the moisture cannot readily escape, especially if the floor is covered with kamptulicon, as in billiard rooms. The use of "Silicate cotton" overcomes the difficulty, and is advantageous for other reasons. "Lime-turf" has also been suggested; it is a substance formed by mixing pulverized peat with slaked lime and water, and well drying.

Skirtings and dados should not be fixed till the walls are dry. They, as well as pipe casings, are peculiarly

susceptible to dry-rot, and form channels whereby the fungus can spread throughout the house. Holes bored in the skirting at intervals, alternately top and bottom, would help to ventilate the closed air space behind. If however the joinery *must* be fixed before the walls are properly dry, "adamant plaster" may be used with advantage. Where walls are locally damp, they may be covered with "Willesden Waterproof Paper."

Many preservatives have been suggested, and many patents taken out for securing timber from dry rot,—by steeping in corrosive sublimate (mercuric chloride $H_gCl_2$) in Kyan's process, by injecting creosote under pressure in Bethell's, zinc chloride in Burnett's, and copper sulphate in Boucherie's. Of these, creosoting seems to be the most successful. Creosote is obtained in the distillation of coal tar, and probably owes its antiseptic properties to the presence of crude carbolic acid, which could not be used by itself, as it is slightly soluble in water. For creosoting, sapwood is better than heartwood, as it is more porous and absorptive. The effects attributed to creosote are as follow:—(1) It coagulates the cell contents, thus giving solidity to young cells. (2) Absorbs oxygen from the cells. (3) Resinifies within the cells, and so excludes air and moisture. (4) Acts as a poison to fungi.

When, however, timbers are built into a house, it is impossible to impregnate them with poison. If they are attacked with dry rot, it will first be necessary to find out the extent of the disease. To do this, the soundness of the wood should be tested by piercing it with a penknife, especially where it looks discoloured. Here and there it should be bored with a gimlet, and the contents withdrawn should be examined; if rotten, it will crumble to fine powder. The wood should be tapped with the gimlet handle, and if it gives a dull sound, decay has probably set in. Another means of detecting decay is to listen at one end of the beam while it is scratched with some instrument at the other; if the fibres are intact, the sound will be readily and distinctly transmitted. Often the wood will show shrinkage-cracks, and present the appearance of having been charred (Plate I., Fig. VIII.), the air will smell close and musty, and the fungus will probably betray itself, either in small greenish-brown or red patches of decayed wood, or more definitely in delicate outgrowths of snowy white resembling swan's-down, or in felted strands of a brown or slatey colour.

If any fructifications, glistening with dew drops, should be discovered, it would be well to saturate them with oil, with extreme care, to prevent the spores from falling or blowing about, and then, having removed them with a knife, to burn them immediately in the open air.

Every trace of fungus should then be scraped from the timber, brickwork or wherever it is found, and the surface of the soil, if exposed, should be removed, for it will probably be permeated with hyphæ, and certainly will contain spores: the whole should then be burnt without delay.

If the timber is at all badly attacked, it would be better to cut it out, burn it, and replace it with new.

If this cannot be done, the beams should be soaked with corrosive sublimate dissolved in methyl alcohol. Methyl alcohol has great penetrating power, and acts as a vehicle to convey the corrosive sublimate into the texture of the wood, evaporating in time, and leaving the corrosive sublimate behind to do its work. The inflammable nature of methyl alcohol must not be forgotten.

Carbolic acid, or a strong solution of copper sulphate (blue vitriol) in boiling water may be substituted. The walls and concrete floor (if any) should be washed with carbolic or sulphuric acid, or Condy's fluid; and the air might be disinfected with advantage by burning sulphur.

In a slight attack, the wood may be covered with hot lime wash.

Notwithstanding however, the fact that decayed wood will absorb the washes more readily than sound, these do not penetrate very deep, and as only those parts of the mycelium are killed which are in contact with the poison, the deep-seated hyphæ may remain as active as ever; the rot is not stayed, but its ravages are now hidden from view.

The beams should not be painted or tarred, for although it might prevent a spore from germinating on the surface of the wood, it would imprison the moisture, and if only an inch of live mycelium was left within the wood, it might soon begin again to grow and flourish in such favourable surroundings. Except in a slight attack, then it is better to take timbers out and burn them, and then replace by new; taking every precaution that the conditions favourable to fungus growth, which have been already enumerated, are no longer fulfilled, and remembering that it may be necessary to do something more than merely insert air bricks to insure a draught. The saws and other tools that have been used in cutting the decayed timber should be dipped in carbolic acid.

In conclusion, I would say that dry rot, while it may be readily guarded against, is not so easily eradicated when it has once obtained a hold, so that here as elsewhere "Prevention is better than Cure."

NOTE I.—Reference has been made to *Polyporus vaporarius* as the fungus producing "red rot." I may add that Professor Ward, quoting Professor Hartig, who has studied the life-history of this fungus, says, that, unlike Merulius, it is found in the wild state in the forests. The spores settle on the surface and in the cracks of the felled timber, and when the logs are floated down the rivers to the timber yards, they swell up, the cracks close and imprison the spores. Germination now takes place, and the hyphæ extend along the crack, so that when the timber after having been stacked comes to be sawn up, it exhibits deep furrows filled with red powder. The close hold of the ship developes and spreads the disease, and it is therefore quite possible that timber built into a house contains spores within it.

NOTE II.—*Wet Rot* is not the result of fungus growth, though the ultimate condition of the decayed wood is practically the same. The process of decomposition, called by Liebig *Eremacausis*, consists in the oxidation of lignin and other substances in presence of air and water, the oxygen combining with the carbon to form carbonic acid (carbon dioxide) and with the hydrogen to form water. The hydrogen however becomes more rapidly oxidized than the carbon, so that the latter remains in excess, and a brown snuff-coloured powder results, which has a larger proportion of carbon than the original woody fibre. Moisture is necessary to the process, which takes place in the open air, and 60° F. the most favourable temperature.

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