peninsula untouched by the narrow stream which must have passed south of the equator. But 14 days afterward, the haze arrived in full force, and produced the green suns and red glows throughout Ceylon and Southern India, shortly afterward appearing in Aden and the Soudan. We also find the glows at New Ireland, 3,200 miles due east from Krakatoa, in four days after the last explosions. In all these cases the transportation was comparatively slow, and probably due to atmospheric currents.

We need to consider the adequacy of the eruption of Krakatoa to have produced atmospheric effects of such magnitude and extent, not only "belting the globe with flaming skies," as in September, but by November enveloping the entire sphere in these fiery glares. Can Krakatoa be shown to have probably ejected a quantity of tenuous matter sufficient for this result? And can it be believed to have delivered such matter at such a height that in its descent it would form a haze canopy from 30 to 40 miles above the surface?

We have absolutely and precisely traced the glows to their source, and so have the right to affirm that Krakatoa proved its colossal capacity to emit these vapors in such quantity and to such a height, by having actually done so. It is the objector's part to prove that it could not have done so, and did not. But waiving this advantage, we cite a preliminary official report on the nature and effects of the eruption of Krakatoa, made by Mr. R. D. M. Verbeek.* He makes an estimate of the quantity of those solid ejecta of the crater which were so coarse as to be speedily precipitated. This amounted to 18 cubic kilometers, or 4.5 cubic miles, two-thirds of which fell as ashes and pumice within a radius of nine miles. He believes that at least an equal mass was delivered at the highest parts of the column in the form of vapors and impalpable dust. It would be easy to present considerations to show that this finer portion must have vastly exceeded the coarser. But this might be speculative. We know that four and a half cubic miles of solid matter would overlay the entire atmosphere of the globe with a solid film of one seven-hundredth of an inch in thickness. This would doubtless be equivalent to many miles in thickness of such tenuous vapor and dust as have been floating in the upper ether.

As to the height of the column of ejecta emitted from Krakatoa at its highest activity, some estimate may be formed from known facts. The heaviest throes were very precisely determined† to have occurred at 9:55 and 10:45 A. M. on August 27. The latter one was immediately followed by a continuous downpour of mud and ashes upon the ship Charles Bal, then 30 miles distant.‡ Seventy miles away, trees were extensively shattered by the weight of wet ashes.§ Batavia, 100 miles away, was covered three inches deep with white ashes during the hours of total darkness following the greatest eruption. It seems impossible to find room for these facts on any estimate of the height of the eruptive column as less than one hundred miles. It is true that light ashes might have great lateral diffusion from a column of far less height, but mud and wet ashes must have plunged quite directly downward, so that a lateral throw of 30 to 70 miles must involve a vertical ascent of not less than one hundred.

The height supposed would have driven the eruptive column entirely through the atmosphere and far above it, so as to deliver its contents over the surface of the atmosphere, to settle slowly down through its upper strata.

That the great column did actually thus lift and rend asunder the mighty mass of the atmosphere above the crater is made probable by the unique oscillations of the barometers. A series of atmospheric waves was sped three times around the globe at the rate of 700 miles an hour.¶ The length of each undulation was one million meters, that of the lowest audible sound waves being 24 meters. Twenty miles away from the crater the mercury rapidly oscillated between the 28th and 30th inches. It is thus evident that in the vicinity of Krakatoa the upper layers of the atmosphere were swinging up and down through a vertical distance of from ten to twenty miles every 15 minutes. What could have done this less than an explosion driving clear through its entire depth?

As general evidences of the ultra-colossal character of the Krakatoa explosion may be added the following:

1. The waves driven upon the coasts of Anjer and Merak, 30 miles away, were found to have exceeded 35 meters, or 112 feet, in height.¶ Over the entire Anjer plain, fifteen miles by five, the inundation had uprooted every tree, and coral blocks of from 20 to 50 tons in weight had been torn from the bed of the sea and borne inland two or three miles.**

2. The detonations of the eruption were heard throughout a circle whose radius is 1,800 geographical miles,†† equal to one-fifteenth of the surface of the earth. Yet the heaviest could not be heard within a radius of 40 miles from the crater. The sounds must have proceeded from tremendous rendings of the air at an immense height, whence the sounds were easily spread to vast distances, while from localities beneath, the massive torrents of descending ejecta cut off the sounds like a wall.

3. Ashes fell‡‡ at Singapore, 335 miles; at Buncalis, 915 miles N. W.; at Keeling, 1,200 miles S. W.; on the Australian coast, 1,050 miles E. S. E.; on the Arabela, 970 miles W. N. West. The entire area of ash fall was officially estimated as at least 750,000 kilometers,§§ or as large as the Southern States east of the Mississippi.

The history of the eruption shows that upon the collapse of the mountain, on the morning of the 27th, the eruptions became submarine;¶¶ the ocean waters rushed into the burning depths. Under the pressure of many miles of water the lava and the waters commingled and struggled with geyser-like discharges of augmenting violence, until finally there arose a continuous column of white hot water and lava. Through the wide throat, apparently three miles in diameter, the

Locality.	Lat.	Long.	Date.	Distance.	Hours.	Velocity.	Great Sun.	Red Glow.	Reference.
Krakatoa....	6° 10' S.	105° 30' E.	Aug. 27th, A. M.						
Mauritius....	20° 20' S.	57° 40' E.	" 28th, P. M.	3,600	30	120		R. S.	Nature, Vol. 30, p. 279
Seychelles....	4° 30' S.	55° 20' E.	" 28th, P. M.	3,480	30	116	G. S.	R. S.	" " 30, 280
Trinidad.....	10° 30' N.	61° 26' W.	Sept. 1st, A. M.	7,420	90	82	G. S.		" " 29, 133
Barinas, Ven....	5° 25' N.	1° 15' W.	" 2d, A. M.	11,600	127	91	G. S.	R. S.	" " 28, 577
Panama.....	9° — N.	79° 35' W.	" 2d, A. M.	12,220	128	96	G. S.		" " 29, 76
C. S. Hurlburt...	17° — N.	125° — W.	" 3d, P. M.	16,000	201	80		R. S.	" " 29, 549
Fanning's Island.	2° 44' N.	70° 22' W.	" 4th, P. M.	18,400	218	84	G. S.		" " 29, 549
Jennie Walker...	8° 20' N.	155° 25' W.	" 4th, P. M.	18,200	218	84	G. S.	R. S.	" " 29, 549
Zealandia.....	5° — N.	163° — W.	" 5th, A. M.	18,800	230	82	G. S.		" " 29, 181
Maalaea.....	20° 49' N.	156° 28' W.	" 5th, A. M.	18,300	229	80		R. S.	" " 29, 573
Honolulu.....	21° 17' N.	157° 52' W.	" 5th, P. M.	18,400	241	76	G. S.	R. S.	" " 29, 174
Strong's Island...	5° — N.	162° — E.	" 7th, (6) P. M.	21,100	256	83	G. S.		" " 30, 537
New Ireland....	5° — S.	152° — E.	" 1st, P. M.	3,200	107	30		R. S.	" " 29, 259
Madras.....	13° 13' N.	80° 12' E.	" 10th, A. M.	1,900	332	6	G. S.	R. S.	" " 29, 28
Ongole.....	15° 32' N.	80° 8' E.	" 10th, P. M.	1,900	342	6	G. S.	R. S.	" " 28, 576
Soudan.....	15° — N.	32° — E.	" 24th.	5,100	672	8	G. S.		" " 29, 181

vast column drove upward, expanding and exploding as it flew into steam and pumice, till, reaching one hundred miles or more in height, its mingled solids and liquids had exploded in the vacuum into thinnest ether.

The ashy ejecta, as analyzed, were mainly of glass in the form of pumice, together with the solid constituents of sea water.* This vitreous matter, being comminuted by the force of the explosions to dust of ultra-microscopic fineness, formed, together with the vaporized sea water, a vast bulk of extreme tenuity and lightness above the atmosphere. Falling thence upon the upper strata of the atmosphere, and precipitating its coarser dust, its finer portions have continued suspended for more than two years in their ethereal encampment, and there are likely to abide for many years to come.

From the beginning, the white sun-glow has been very uniform, while the night-glows have been quite irregular, although it is believed they have always been perceptible. In the northern tropics, there has been a marked increase of brilliancy and continuity during each of the two winters. Probably the haze is distributed through the atmosphere in unequal and irregular drifts.

John Aitken's demonstrations of the necessity of dust nuclei to the formation of ice spicules in the atmosphere† indicate that such ice particles probably play a prominent part in the glows. Not improbably they would be in larger quantity in the tropics during the winter; and so the glows increase at that season. Varying atmospheric conditions would also at all seasons vary the amount of congelation.

In conclusion, the writer takes the opportunity to venture the surmise that a thorough study of the Krakatoa smoke belt of September, 1883, and of its dynamic conditions, may furnish material aid in elucidating the still mysterious problem of the belts of the planet Jupiter.

FUNGI INDUCING DECAY IN TIMBER.‡

By P. H. DUDLEY.

THE fungi are leafless, flowerless plants, containing no chlorophyll, and instead of propagating by visible seeds, have only microscopic spores, which are freely disseminated by the air to resting places. If proper conditions for germination are present, the spore sends out a delicate mycelium, inducing sooner or later a decomposition of the structure of its host, in order partly to build up its own; and it is only later, when fructification takes place, that the presence of a fungus may be suspected.

The species of fungi named by writers as causing the so-called "dry rot" in timber are, namely: *Merulius tachrymans* Fr., *Polyporus hybridus* Fr., *Polyporus destructor*, *Telephora domestica*, *Boletus destructor*, *Cerulius vastator*, *Agaricus mellus*, and *Dædalia vorax*. The names of the first two are generally mentioned and do to duty for all occasions. The second is the one found so destructive to the English naval vessels built of oak.

The mycelium of a fungus is not sufficient, at present, for mycologists to identify species, and this is one reason why the list is so small. I have only found *Merulius tachrymans* Fr. a few times in bridges and cars, never on ties. The others of the list I have not found, but in their place many which are sufficiently destructive to satisfy all needs without any importing foreign varieties. While at this time I only add a few names of species, there are hundreds yet to be identified which aid in inducing decomposition of wood:

Lentinus lepideus Fr., scaly lentinus.
Agaricus americanus.
Polyporus applanatus Fr.
Polyporus versicolor Fr.
Polyporus lucidus Fr.
Polyporus salicinus Fr.
Polyporus nidulans Fr.
Polyporus sulfureus Fr.
Polyporus gilvus Fr.
Polyporus pergamenus Fr.
Polyporus abietinus Fr.
Polyporus pinicola Fr.
Lenzites villos Pk.
Hydnum septentrionale Fr.
Fistulina hepatica.
Dædala confragosa Pers., lentinoid form.
Panus stypticus Fr.

I have placed *Lentinus lepideus* Fr. first on the list, for in this immediate territory it is the one so destructive to timber of yellow or Georgia pine (*Pinus palustris* Mill.). I have also found it upon *Pinus mitis*. Being the first to call attention to its destructive influence, its brief technical description will not be out of place, as given in Cooke's "Handbook of British Fungi."

"Pileus fleshy, compact, tough, convex, then depressed, unequal, pallid-ochraceous, broken up into darker spot-like scales; stem stout, rooting, tomentose, or

scaly; gills sinuate, decurrent, broad, torn transversely striate, whitish. On stumps of firs, rare (U. S.)." Monstrous forms occur in dark situations with or without a pileus. On the gills or laminae are borne the spores, 3.5×8 micro-millimeters, curved, and one end apiculated, which drop out and are carried by the wind to some resting place. The mycelium fruiting only under very favorable conditions, the fruit is not easily found. A specimen is here shown. I have seen many thousands of ties destroyed by it without finding the fruit. Its mycelium is very abundant, and pierces the coarser cells of the wood with great rapidity, generating sufficient moisture, having an acid reaction, to carry on its destructive work, provided external currents of air and heat are not sufficient to dry the wood.

Examining many pieces of bridge timbers which were horizontal, I found where they had rested on others sufficient moisture had collected to germinate the spores, and the mycelia had followed the longitudinal cells from each way, until they had met in the center between the supports. The outer portions of the timber remaining dry did not allow the moisture to escape, and the fungus was destroying the inside, while the outside looked sound. I have here a part of a bridge plank. The moisture accumulated where it rested on the joists, the mycelia working each way and upward, leaving a thin portion of one-eighth to one-quarter of an inch in thickness, giving the appearance that it was all sound. The abundant fructification during a brief, warm rain in September, 1883, was the first indication of the destruction which had taken place. In ten minutes' walk from this hall, we could see many thousands of feet of timber destroyed by this fungus, while the cause of decay is hardly suspected.

The upright cells or tracheids composing the annual ring of the *Pinus palustris* Mill. are of two kinds; one of thin, and the other of thick walls. The former fill the inner part of the ring, the latter the outer portion, giving the great strength and hardness to the wood. Interspersed through the ring are a few resin ducts. In decay induced by its special fungus, the mycelium often separates some of the annular layers, and in most cases the thin-walled cells are softened first. On railroad sleepers, larvæ from one-sixteenth to one-eighth of an inch in length eat and bore through the softened fibers, so that in ties of four to seven years' service we often find little more than a series of nearly separated shells. The mycelium of this fungus, once in the road-bed, is, in summer time, ready to attack new ties of this timber as soon as put in the ground. I have noticed ties, taken up after a short service of six to eight months, which were covered on the bottom by the branching mycelium, and after drying one-eighth to one-fourth of an inch in depth, would crumble to dust. This is the so-called *dry rot*. It takes much longer for the mycelium to destroy the yellow-pine sleepers from the bottom and sides than when it has access to the ends. In the first case, it must nearly destroy the small medullary cells to reach the various rings, while from the end it has a larger area of the rings, which it readily follows. Painting the ends of the timber offers but little protection if the slightest opening occurs, as a spore can enter, grow, and carry on its destruction for a long time before it shows exterior decay.

The structure of each longitudinal cell of this wood consists of three lamellæ, a thin inner one surrounding the lumen, then a thicker one, then a thin outer one which joins that of the adjacent cell. Chemicals which dissolve the latter do not attack the other two, and *vice versa*; thus they can be separated. In the decay of this wood induced by the fungus described, the outer layer seems to be the last destroyed in many of the cases I have studied.

The decay of the yellow pine is a matter of increasing importance to many of the railroads in this vicinity, as they are depending more upon the use of this timber for ties than formerly, while for bridge timber and plank it is indispensable; and it would be difficult to supply its place in the construction of the frames of cars.

The mycelium of *Lentinus lepideus* Fr. is composed of small branching filaments measuring from one to two micro-millimeters in diameter. With the mycelium I generally find an abundance of crystals of one form of oxalate of lime. Sometimes small embedded cells of other fungi are seen; also other minute forms in adherent masses, the individual cells being quite beyond the definition of present microscopes. These lower species, which act as the allies of *Lentinus*, are difficult to trace. The destructive power of this fungus is very great, and it is causing enormous losses to users of timber, which are not realized or even suspected.

The remaining species of fungi in my list are those which I have thus far identified as inducing the so-called "dry rot" in various woods. *Polyporus versicolor* Fr. is very common, as I find it upon the sapwood of the white and red oak, and chestnut ties; also upon the sapwood of chestnut and locust posts, and on the sapwood and heartwood of wild cherry, and once on hemlock boards. As a rule, it is more abundant on sapwood of the oak than on chestnut ties. My observations refer to the entire length of the Boston and Albany R.R., and parts of many other roads in Massachusetts. On the heartwood of the white oak

* Nature, vol. 30, pp. 10-14.

† Nature, 30, 12.

‡ Nature, 29, 140.

§ Leisure Hour, July, 1885, p. 487.

¶ Nature, 29, p. 181.

¶ Nature, 30, 14; Leisure Hour, Sept., 1885, p. 636.

** Leisure Hour, August, 1885, p. 556.

†† Nature, 30, 10.

‡‡ Nature, 30, 13.

§§ Nature, 30, p. 13.

¶¶ Nature, 30, p. 12.

* Nature, 30, p. 13.

† Nature, 29, p. 403.

‡ A paper read before the New York Academy of Sciences, January 4, 1886. From the Transactions of the Society.

ties, I have only identified *Polyporus applanatus* Fr., which also attacks the sap-wood of many other kinds. The heart-wood of chestnut ties is not so quickly attacked by fungi as some other woods, since most of them are removed on account of mechanical destruction of the fibers under the rails before decay takes place. I have several samples of the mycelium in chestnut tie (this one from the yard of the Grand Central Station), but have only found a few undeveloped efforts of fructification.

Fistulina hepatica was found on chestnut wood. The special habitats of the others need not be mentioned. These higher species of fungi are some of those which induce the so-called "dry rot" in timber, so often considered as taking place when the wood is perfectly dry. This is a misconception, as it is impossible for decay to commence without moisture, sufficient heat, and access of air to supply the amount of oxygen needed in the reduction of the tissue to lower compounds. "Dry rot" was named from the effect produced, and to distinguish it from the so-called wet rot. It has been an unfortunate designation, misleading many people, and causing them to believe that timber will rot when dry, and hence proper precautions have not been taken to prevent decay, on the supposition that it would occur in any event. When a fungus has attacked a piece of timber, and subsequent dryness arrested further decay, the tissue affected cracks and crumbles to dust, and people often tell me "there is the evidence of dry rot destroying dry timber"—an effect mistaken for a cause.

The mycelia and fruit of the fungi given in my list all show an acid reaction; and in the decayed yellow pine an acid was associated with a gelatinous mass, insoluble in alcohol, but partially so in hot water. A drop of the latter on evaporating left a gummy residue, and small crystals formed similar to those of oxalate and phosphate of calcium. By adding other reagents, a variety of different crystals were produced.

From the fruit of *Polyporus pinicola* Fr. a considerable quantity of phosphoric acid, potash, and lime was obtained. The watery extract from this fungus nearly resembles, in composition, the artificial preparations used for the cultivation of moulds, and is quickly transformed by them in a few hours, showing an abundance of yeast cells and rhombohedral crystals. This is a feature of great significance, being an important aid in hastening decomposition, at least. If there is a free aerial growth of the fungi, drawing its supply of oxygen from the air, there is a rapid destruction of tissues, and little is left of the structure. When the air is limited, there is a slower destruction, and more of a fermentative action. In the latter, in the many cases so far studied, I have found an abundance of crystals. The so-called "wet rot" is the result of slow fermentative action, and, when produced by the lower order of fungi, *Sphaeriacei*, the mycelia found in the cells are dark colored and jointed. These mycelia are sometimes of long, and again of nearly spherical cells, which pierce the cell-walls of the wood and fill the medullary rays, making them look dark. Some species fruit in the cells near the outer surface. I have a piece of one of the original oak ties put down and completely covered by sand and paving, in the Grand Central Station, in 1871. It was taken out last month. The strength of the wood is destroyed, and it will crumble on further drying.

I found several budding cells of ferment similar to the yeast plant in appearance, and a few cells of the genus *Protococcus*, and an abundance of dark hyphæ, which give color to the wood in streaks. In what were checks in the wood when put down are the remains of perithecia of some of the *Sphaeria*. The action here was very slow but sure; the outer lamella of each cell being destroyed more than the others. By wetting and careful manipulation, they can be separated, showing their form more perfectly than those obtained by the ordinary maceration. Some of the *Sphaeria* grow under the bark of live trees, sometimes killing them, and are ready, as soon as vital functions of the tree cease, to pierce their host with the abundant hyphæ, and carry on their work of destruction.

I find on unpainted telegraph poles many places where the growing perithecia have burst and broken one to two layers of the wood cells; and this is repeated as fast as the proper conditions ensue, thus aiding in the mechanical destruction of the tissue. Near the ground line, other fungi send out mycelia which follow down the cells of the wood rapidly, but pierce the wood transversely in a slower manner. As the mycelia get farther away from the air supply, the fermentative action becomes more marked. I mention these points for the reason that, when examined separately, it is hard to understand their connection; and it is the consideration of these two extreme conditions which has led to part of the controversy regarding the relation of fungi to decaying wood. There is less real distinction between the so-called "dry rot" and wet rot than is usually supposed, as both must have moisture, a suitable temperature, and some air to induce decay. Though the final result is the same in all cases, it does not occur in the same way in all kinds of wood.

The subject must be treated specifically, and not in the general manner adopted by writers. Each species of tree has special fungi, as it has insects, which are not found to any extent upon other kinds of wood. Red cedar, cypress, yellow pine, are not affected, as a rule, by the same fungi which quickly destroy the sycamore, maple, hickory, and basswood.

The structure of all these woods, their stored products, and the intercalated substances in their cellulose walls, differ from one another, as do each of our extensive flora of over four hundred species, and they are distinguishable under the microscope by a difference of cell structure, arrangement, and chemical products as readily as the botanist recognizes them by exterior growth of form, leaves, flowers, or fruit.

The chemical composition of wood is not practically alike, as recently stated, but differs even in the sap-wood and heart-wood of the same species. Some of the woods have compounds in their cells easily induced to decompose and start the wood tissue, while others have different compounds, requiring inducing agents of greater intensities to begin decay.

A study of the growth and functions of the fungi enables us to understand why, in practical operations, it is so difficult to prevent large timber from decaying internally, while remaining sound upon the exterior. The spores so abundant in the atmosphere find ready lodgment in the checks of the timber before it is

thoroughly seasoned. These are inclosed by boarding painting, or exterior treatment, or even exposed to the sun so as to dry the outside and thus prevent the evaporation of the internal moisture, and the spores germinate and either grow a mycelium or set up the fermentative action, destroying the inside of the timber, leaving a mere shell outside. This was the case with the painted Howe truss bridges erected for the Western railroads, many of them rotting in four to five years. Roads which were too poor to paint the bridges the first year, found they lasted longer. These were very instructive lessons to me, and in 1873, when designing and erecting a series of long railroad trestles, I made my posts six by eight inches, using two, set three inches apart. This allowed them to season, and gave me about the same factor of safety as one ten by ten, which would not season, but would rot in six to seven years. And my trestles are still in use.

The exterior coatings intended to preserve the Nicholson pavement blocks was about the most effective means which could have been used to destroy them. Many other failures of treated timber are due to this same cause, namely, inclosure of the spores, their growth and fermentation.

I have here a piece of wood, used for the sheathing of freight cars, which has already undergone initial decay. Its cells contain the germs to destroy it. A coat of paint on the outside, and a little moisture inside the car, would complete the decay. Cars sheathed horizontally retain moisture in the tonguing and grooving longer than those vertically sheathed, and in consequence they are destroyed sooner by the growth of fungus, seemingly a trifling affair, but really of great financial importance.

Some efforts to preserve certain timber for some places have been successful; but attempts to preserve all kinds and sizes on the same general plan have resulted in many costly failures, and large corporations have lost faith in such efforts to prolong the service of the wood. Why some succeeded and others failed hardly excited a query, much less an investigation; and hence good and poor methods were equally condemned.

The proof that untreated wood is stable in some conditions is very abundant. Timber and plank in the roofs of foreign buildings are reported to be in sound condition after a service of eight to ten centuries. Piles which were submerged in water and mud are also reported sound after a long service.

We have much older evidence of the preservation of vegetable and animal tissue than that contained in written records. I have sections of coniferous branches supposed to have formed part of the last dinner of the mastodon exhumed in Jamestown, N. Y., some years since, and the wood fiber is probably many thousand years old, as the mastodons have long since been extinct. Dr. Hubbard exhibited here last winter a piece of the Siberian mammoth skin, which must have remained in the ice for thousands of years. It was dried, and in this condition will last indefinitely. Last week Dr. Hubbard gave me a piece, to which I have applied moisture, and it is now undergoing decomposition—furnishing a rare morsel for countless bacteria.

The evidence of the destructive influence of fungi is older than that of the preservation of tissue. In the beautiful agatized woods of the Triassic period, recently shown here, I find the mycelia of the fungi, inducing their decay, preserved by the infiltrating medium which agatized the woods.

We daily see posts and telegraph poles, after three to four years' service, decaying near the ground line, but above in better condition.

By comparing the difference of service, it can be seen how little change is required to render unstable what would be stable under other circumstances. In roofs there are dryness, circulation of air, plenty of spores, and sufficient temperature to germinate, but the necessary moisture is absent. In the case of submerged piles, there is excessive wet, with insufficient temperature, and exclusion of air, either to carry spores or permit them to grow. In the case of the posts and telegraph poles, we have the spores, the moisture, and the necessary temperature in summer for germination, and decay ensues. The last stated conditions are those in which the great bulk of railway sleepers are placed, and decay will result unless precautions are taken to prevent it. It is not realized how thorough these precautions must be until thousands of decaying sleepers have been examined. In many cases it seems as though each individual fiber must be protected, not only to prevent the germination of spores, but from the stronger attacks of mycelia, which are in many old roadbeds.

To obtain the best results, the kind of wood for the service must be first considered. However, this general statement can be made—the tissues of all wood remain sound or decay, according to surrounding conditions. An inducing cause is necessary to start decomposition, which is the function of some of the fungi.

In the discussion, Prof. Trowbridge remarked upon the great practical importance of the study, and fully agreed with Mr. Dudley that moisture must be present to start decay. Wood in the roofs of buildings had lasted over two thousand years, and was still sound. The bridges put up by Towne, which gave him his great reputation, were covered, the timber kept dry, and some of them were still in use, and sound. In reply to his question whether there was any process which would preserve the timber, Mr. Dudley said that could not be answered generally. Small sizes of some kinds of timber had been preserved for some length of time, but there was, as yet, no successful treatment for all kinds of timber for all conditions of service.

Mr. Dudley, in answer to Mr. Collingwood, said that microscopic examination of different woods showed more in relation to the strength than the durability, though it would determine whether the stored products in the medullary rays were in the form of starch, the most stable form, or in sugar, glucose, etc. The catalpa, by its structure, does not indicate the great durability ascribed to it. Woods which have large bundles of medullary rays filled with compounds are more easily induced to decay, as a rule, than those which have smaller bundles. The microscopical examination would show at once whether incipient decay had commenced. In cutting timber and preparing it for use, it was impossible to prevent the access of numerous spores of various fungi in the air, and when proper conditions were present, they would germinate.

Thoroughly seasoned wood could be painted with advantage, otherwise it was an injury, because it held

the moistened spores in the wood, and decay would take place.

Mr. W. Barclay Parsons gave illustrations from his experience of the variation in the durability of timbers and bridges under like conditions, and discussed the matter of painting and covering bridges. In one old bridge, the oak posts were sound, but the pine chords were gone.

Mr. Dudley said it was economical to paint bridges when the timbers were small and well seasoned; but the joints and ends of the timber must be well protected. Timber should be seasoned under cover, and not in the sun. He thought bridges were better covered than painted.

Dr. Schoeney discussed the subject of fungi attacking wood as being analogous to human diseases, and its bearing upon the germ theory. In answer to his question, Mr. Dudley said he thought the mycelium could penetrate the epidermis and corky layer of living trees if moisture could soften them.

Dr. Britton briefly described the life history of these higher fungi.

President Newberry commended the paper, and spoke of the importance of the study. He had in his museum specimens of wood from the Egyptian catacombs, which, by being kept dry, had been preserved three thousand years; moisture is necessary for decay, and there is no "dry rot."

Mr. Dudley said the first Nicholson pavement was of seasoned wood, while later unseasoned wood was used, and the pavements were short-lived. He thought that it was practicable to exhaust air, and fill pores of small timbers with antiseptic fluid, but not of all kinds of large timbers.

BARK BREAD.

MOST travelers in Norway have probably had more than sufficient opportunities of becoming acquainted with the so-called "fladbrod," flat bread, of the country. Few, however, among them who have partaken of this dry and insipid food may possibly be aware that in many districts, more especially in Hardanger, the chief ingredient in its composition is the bark of trees. This substitution of an indigestible product for *bona fide* flour is not necessarily a proof of the scarcity of cereals, but is to be ascribed rather to an opinion prevalent among the peasant women that the bark of young pine branches or twigs of the elm is capable of being made into a thinner paste than unadulterated barley or rye-meal, of which the Norse housewife, who prides herself on the lightness of her "fladbrod," puts in only enough to make the compound hold together.

The absence of any nutritive property in bark bread, whether made with elm or pine bark, and the positive injury it may do the digestive organs, have of late attracted much notice among Norwegian physiologists, and the editor of *Naturen*, with a view of calling the attention of the public to the subject, has, with the author's permission, reprinted some remarks by Dr. Schübeler on the history and character of the bark bread of Scandinavia. From this source we learn that the oldest reference to the use of bark bread in Norway occurs in a poem ascribed to the Skald Sighvat, who lived in the first half of the eleventh century. In the year 1300 the annals of Gothland record a season of dearth, in which men were forced to eat the bark and leaf-buds of trees, while then, and during the later periods of the middle ages, the frequent failure of the crops in all parts of Scandinavia led to the systematic use of the bones and roe of fishes as well as the bark of trees as a substitute for genuine flour; and so extensively was the latter substance used that Pastor Herman Ruge, who in 1762 wrote a treatise on the preservation of woods, has drawn attention to the almost complete disappearance of the elm in the Bohus district, which he ascribes to the universal practice in by-gone times of stripping the bark for the preparation of bread.

In Nordland and Finnmark the root of *Struthiopteris germanica* and other ferns, as well as the leaves of various species of *Rumex*, have been largely used with barley-meal in making ordinary bread as well as "fladbrod." In Finland the national "pettuleipa" (bark bread), which was in former times almost the only breadstuff of the country, still ranks as an ordinary article of food in Kajana and in the forest regions of Oesterbotten and Tavastland. Here it is usually made of the inner layers of the pine-bark, ground to a meal, which is mixed with a small quantity of rye-flour to give the requisite tenacity to the dough. The Finlanders of an older generation showed marvelous ingenuity in composing breadstuffs, in which scarcely a trace of any cereal could be detected in the mixture of bark, berries, seeds, bulbs, and roots of wild plants, which they seem to have accepted as a perfectly legitimate substitute for corn bread. In the interior of Sweden, according to Prof. Save, the best bread of the peasants consisted till the middle of this century of pease, oats, and barley-meal in equal proportions, while in the ordinary daily bread the husks, chaff, and spikes of the oats were all ground down together. In bad seasons even this was unattainable by the Dalekarian laborer, who had to content himself with pine-bark bread.—*Nature*.

THE COMPOSITION OF AIR.

SOME recent experiments to determine the average composition of atmospheric air have been described to the Académie des Sciences by MM. Muntz and Aubin. This order of researches was initiated by Regnault, who established the mean composition of the air by multitudinous analyses of the contents of glass tubes sent by himself to correspondents in different countries, who opened these tubes, and, after they were filled with the air of the locality, returned them to Paris, where the analyses were made under conditions permitting the attainment of great exactitude. MM. Muntz and Aubin have not been able to improve upon the method of Regnault; but they took advantage of the French scientific mission to Cape Horn to secure fresh samples of air from a locality where it might be supposed to possess a perfectly normal composition. The mean of numerous samples taken under different weather conditions shows the proportion of oxygen to be 20.864 per cent. by volume. The air of Paris, according to two samples taken in a street in July, contains 20.92 per cent. of oxygen. Regnault's determination for Paris air was 20.960; and for all his analyses the maximum and minimum limits were 21.015