U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

DISEASES OF SHADE AND ORNAMENTAL TREES.

BY

B. T. GALLOWAY AND ALBERT F. WOODS,

Chief and Assistant Chief, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

[REPRINTED FROM THE YEARBOOK OF THE DEPARTMENT OF AGRICULTURE FOR 1896.]

CONTENTS.

ILLUSTRATIONS.

DISEASES OF SHADE AND ORNAMENTAL TREES.

By B. T. Galloway and Albert F. Woods,
Chief and Assistant Chief, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

GENERAL REMARKS.

Speaking generally, the diseases of trees may be divided into two classes: (1) Those in which conditions of soil and climate are the controlling factors, and (2) those where parasitic enemies, such as insects and fungi, are the principal agents involved. Some of the more important insects were described in the Yearbook for 1895, and therefore the present remarks will be confined for the most part to the diseases in which conditions of soil and climate and parasitic fungi are involved.

No sharp line can be drawn between the two classes of diseases to which reference has been made. If they were controlled by a single set of factors, this might be done, and the question of identifying them would then be a very simple matter. Complications, however, are always involved, and these become more intricate the more they are investigated; in other words, the tree is ready at all times to adapt itself, within certain limits, to surrounding conditions, and in doing this elements of weakness may be developed which will result in disease or death. The adaptability of trees, therefore, to environment is a most important matter in considering the question of diseases, and to properly understand the latter it may be well to briefly review some of the more important points involved in the former.

It is a matter of common observation that different types of soil and climate support different kinds of trees and other plants. It is not always, however, because we find certain kinds of trees growing in certain soils and under certain conditions, that the peculiarities of the soil and surroundings account for their growing there. Such trees may grow very much better under different conditions if an opportunity is offered; otherwise they will continue to grow where they are, at the same time tacitly protesting against their environment by responding to the more suitable surroundings if they appear.

An important matter for consideration in the question of adaptation of plants is the fact that the individual is much more susceptible to changes than is the species as a whole. For example, an individual white oak tree in a moist, warm region would make a growth which would quickly dry up if moved to a region where moisture is deficient,

but where other white oaks were growing, whereas if it had been started from the first in the dry region it would have adapted itself to the conditions and thrived there. Conversely, the tree growing in a dry region or place, if moved to a wet location, is liable to suffer, as it is unable to adjust itself to such a sudden change. It is a common practice to transplant trees from the forest to yards and other places where the conditions of soil and air are quite different from those under which the plant originally grew. In such cases it is difficult to get the trees to live, owing to their inability to adjust themselves to the new requirements. If they do not entirely succumb to the effects of changed surroundings, they may, during the period in which they are trying to adjust themselves, be attacked by parasitic enemies, which will simply result in death in another form.

From such facts as here adduced it would appear that disease or death of trees is largely the result of combinations of unfavorable factors, and that where these latter are favorable to the performance of the normal functions of the trees they might continue to live indefinitely. Unlike an annual or biennial plant, a tree renews itself each year by a thin layer, which forms between the old bark and the wood. This layer is the starting point for the next generation, so that we have a great mass of dead and dying generations within, coated outside with a live generation, which is just as distinct individually from previous generations as a new plant produced from a cutting or bud is distinct from the parent, and which, therefore, strictly speaking, is never old.

As long as the conditions for obtaining food and water from the soil and for conducting these to every part of the tree are favorable and the effects of climate are not detrimental to growth, the living portion of the tree should be as vigorous as ever. These conditions, however, are seldom attained, and as a result the duration of life is long or short according to the ability of the tree to overcome the difficulties in the way of its development. Thus, if there is a continual drain on the supply of soil foods, with no addition, the tree will eventually starve to death or become so weakened that it will succumb to the attacks of parasites; a period of drought may kill many feeding roots, branches, and leaves, and as these decay openings will be left for parasitic fungi; a period of cloudy, wet weather may do the same by asphyxiating many roots and leaves; a severe cold spell may "kill back" young growth and injure the young leaves in the spring; a late, warm, and moist fall after a dry summer may induce a fall growth which can not mature sufficiently to withstand winter cold, and is thus "killed back;" insects may defoliate the branches and borers mine the trunk and limbs, and thus cut off the distribution of food and water and make openings for the entrance of parasitic fungi; parasitic fungi may attack some part of the tree under certain favorable conditions without the tree being previously injured; a tender vegetative growth,

although perfectly healthy and normal, may at a certain phase of development be unable to resist the attacks of certain parasites, while later the parasite may not be able to gain entrance; the chemical composition of the juices, or the prevalence of sugar, starch, and acids or bases, may make it possible for parasites to attack the tissues during certain stages of growth, and thus produce disease.

From the foregoing, it will be seen that any disease, no matter how simple it may appear on the surface, involves complications which require careful study, and it is only such study that will enable the intelligent grower to obtain the highest success in his work.

DISEASES DUE TO SOIL CONDITIONS.

LACK OF FOOD AND WATER.

A disease known as "stag head" or "top dry" frequently results from lack of proper food in the soil. The trouble manifests itself by the gradual death of the top of the tree, the lower branches remaining green, but making little active growth. It is common in forests, especially where the conditions have been changed by cutting out or burning the undergrowth, by greatly thinning out the trees,[1] or by excessive drainage of moist areas. It often appears in parks where the natural undergrowth has been cut out and the trees have been thinned, thus exposing large areas to the sun and the washing effects of heavy rains. In such cases there is at first, as Hartig points out, an accelerated decomposition of the humus which covers the soil. At the same time the manufacture of sugar and starch by the leaves is increased, owing to an increased supply of light. Stimulated by this increase of food, all the benefited trees make a more vigorous growth, dormant buds developing into leaves and branches, especially in the previously shaded lower parts of the trees. This may continue for a few years, or until the stock of humus and other available food material is reduced. The soil then dries out to a considerable depth during the summer, and as a result many of the upper feeding roots are killed, the natural processes which render plant food available are interfered with, and starvation begins. As the soil becomes poorer and poorer the lower branches appropriate most of the food and water and the upper ones, not being able to obtain their share, die.

Trees planted in parks, in yards, and along streets are especially subject to this disease. Growing year after year where there is no addition to the available soil foods, especially nitrogen, and where the soil is dried out by the sun and grass, starvation necessarily follows. The tree therefore gradually stops growing, the branches and limbs slowly die, and other diseases set in, until finally the last branch is dead. Another cause of this trouble is often found in the process of grading, which removes what good surface soil there is, leaving one

[1] Hartig, Diseases of Trees, pp. 270–272.

not only of poor physical quality, but also lacking in nitrogen, if not in other available soil foods. In planting trees in such places a hole, possibly of sufficient size, is dug, and the tree is set in this, probably with some richer soil, which will furnish food for an indefinite period, according to its quality and amount. If the quality of the soil is poor and the amount small, the tree will begin to starve in five or six years; if the quality is better and the amount larger, it will last for a much longer period. But no matter how good the soil may be to start with, unless the food supply is properly renewed it is sure to become exhausted as far as the tree is concerned, and starvation, with all its incidental troubles, will follow. (Fig. 53.)

Preventive measures.—It is evident that a constant supply of proper food is necessary to prevent this disease. If the soil is naturally rich, well drained, and of good texture, little need be done in the way of improving it. Wherever practicable, the ground underneath the tree should not be completely sodded, but should be planted to low-growing, shade-enduring plants, so that most of it may be worked and top-dressed each year, thus keeping up the food supply and the proper aeration of the soil. The poorer the soil the greater the precautions that must be taken in this direction. When trees are to be set in very poor soil, as is often the case in cities, a hole at least 8 feet long, 2 feet deep, and 3 feet wide should be excavated and good soil substituted for that removed. Along streets and walks as large a parking as possible should be left around the tree. Each year this should be spaded as deep as possible without injuring the roots, and then top-dressed with good rotten manure enriched by a sprinkling of ground bone. Grass or weeds should not be permitted to grow in this area, nor should the ground be allowed to become trampled down. If these precautions are taken, the health and life of the trees will be extended many years beyond what they would under less favorable conditions.

IMPERFECT CIRCULATION OF AIR IN THE SOIL.

The proper aeration of the soil has an important bearing on the health of trees. The amount of air and its circulation are affected by the size and arrangement of the soil grains, amount of water present, proximity of pavements, filling, grading, etc. Whatever may be the cause of imperfect aeration, the effects are far-reaching and important. In the first place, nitrifying organisms can not carry on the important process of fixing atmospheric nitrogen in soils deficient in air, especially its most important element, oxygen, while other similar organisms may even cause the destruction of what nitrates there are present. This is particularly true of wet soils and those of very close texture. The presence of much water between the soil grains prevents the circulation of air, and there is consequent loss of nitrates, the most valuable of all soil foods. But aside from this important consideration the plant roots themselves require a plentiful supply of

oxygen in order to carry on their own life processes. Growth can not take place without it, neither can the formation of reserve materials. These processes are especially active in roots. A deficiency of oxygen for roots at once becomes apparent by cessation of growth, and, if too long continued, by the death of the roots, followed by starvation and death of the whole plant.

Trees are often injured in poorly drained soils during a wet period. Of course, if the presence of water is constant and the tree has grown up under these conditions, it will produce many surface and water roots, thus adapting itself to a wet situation. We refer here, however, especially to soils which are too wet only at certain periods—low places, underlaid by hard pan; where ground water comes close to the surface; or in stiff soils, which, becoming saturated, hold water for a long time. The roots produced in the rather dry or moist soil are injured or killed during wet periods, especially the deeper ones, like the taproot and the lower laterals. A prolonged wet period followed by a very dry one is liable to completely kill the tree under such conditions. In some of the close-textured soils of the West and Southwest, naturally deficient in aeration, trees often suffer or are killed during the rainy season, or by excessive irrigation. When the roots are not killed, they are so weakened as to be made subject to the attacks of various root-rot fungi.

FIG. 53.—Stag head soft maple.

Trees planted along the paved streets of towns or cities nearly always suffer from a lack of aeration of the soil. The exchange of gases between the soil atmosphere and the air is greatly retarded by pavements and walks and by the hard-packed surface of roads which are not paved. This trouble is especially liable to occur along streets,

where the ground water is only a few feet from the surface. During prolonged rainy weather the water rises, making the soil wet up close to the surface. The pavement adds here to the evil of poor underdrainage, preventing evaporation and aeration.

Another means of cutting off the soil air is by filling and deep planting. It often happens in grading that soil is filled in around trees, sometimes to a depth of several feet. In naturally well-aerated soils the damage that may result from this practice is not so great or so soon apparent. No special harm may result in such soils if the amount added is not more than a foot in depth, but where it exceeds this more or less rapid asphyxiation of the roots and lower part of the trunk will follow. The tree may not be killed, but it will at least be greatly checked and stunted in growth, making it more subject to other diseases.

The same troubles often result from too deep planting, especially in heavy soils. The deeper roots rot, and the tree makes a slow, stunted growth, and sometimes lasts for many years, when it either dies of its own accord, is blown over by the wind, or death is hastened by some parasitic disease. Large numbers of young trees set only a few inches too deep are killed in this way.

Preventive measures.—In all cases where there is a lack of aeration steps should be taken to keep the ground around the trees stirred. In cities parking must be left, and where the ground is hard it should be frequently spaded to a depth of 6 to 8 inches, as already described. Where the ground has been filled in around the trees, the latter, if not too old, may be saved by removing small patches of bark down to the wood. This should be done at points beneath the soil so as to induce the formation of new roots from the wounds. Some trees, like willows, poplars, beech, and horn beam, but especially shrubs, produce adventitious roots just beneath the surface of the ground, and these are able to preserve the trees though the deeper roots may be killed.

GASES AND OTHER POISONOUS SUBSTANCES IN THE SOIL.

Asphyxiation of the roots of trees is sometimes produced by illuminating gas which has escaped from some gas main near by. It probably also acts as a direct poison. Diseases produced by other poisonous substances in the soil or by too great concentration of substances not poisonous are too rare to warrant their treatment here. The injuries from escaping gas can be remedied only by stopping the leak, and after removing as much of the old soil as possible filling in with fresh, rich earth.

DISEASES DUE TO ATMOSPHERIC CONDITIONS.

As already pointed out, no sharp line can be drawn between the diseases due to conditions of the soil and of the air. As a matter of fact, a weakened state of the tree, due to certain conditions of the soil, will make it all the more liable to succumb to atmospheric

influences. Again, it may happen that very favorable conditions of the soil may start growth at a time when it might be injured by cold or other conditions of the atmosphere.

DESICCATION, OR DRYING OUT.

Young leaves and sometimes tender shoots which have pushed out during a spell of cold or cloudy, moist weather frequently wither and die when suddenly exposed to bright, hot sun. This is ordinarily called sun scald. It is not, however, a true scalding of the tissues, but is due to the fact that the latter lose water more rapidly than they can obtain it, and so wilt and dry out beyond the power of recovery. The excessive loss of water is brought about mainly by the leaves produced in very moist air not being adapted to resist excessive evaporation, even when there is an abundant supply of water in the soil and in the main parts of the plant. The trouble occurs more often in spring, when growth is rapid, and cloudy, moist days are followed by hot, dry ones. Later in the season the death of the margins and tips of the leaves of a great variety of trees, shrubs, and other plants is often observed. This is especially noticeable when a rather moist spring, favorable to growth, is followed by dry and very hot weather. Trees making a poor, stunted growth suffer most, although any tree is liable to injury if the right conditions prevail. In parts of the West and Southwest the disease described is produced in a very short time by hot, dry winds, which sometimes sweep over the country. Frequently the leaves are literally cooked, but oftener the edges wilt, turn red or pale yellow, and then dry up.

Desiccation may also occur in the winter; in such cases parts of the tree or even the entire tree may be killed. Evergreens, especially pines, are frequently seriously injured from this cause. A few warm days occurring at a time when the roots are frozen or when the ground is so cold that it hinders root action, cause the needles to turn reddish yellow and fall. Frequently only the tips of the needles at the ends of the branches are affected, and again young and exposed trees may be thoroughly dried out and killed. Cold, dry winds may bring about the same effects as warm ones with sunshine. Any conditions, in fact, which will cause a more rapid evaporation of water than the roots can supply will, if continued a sufficient length of time, eventually result in the injuries described.

Preventive measures.—In cases such as have been referred to it would be difficult to carry out remedial measures. In most instances the injuries are done before any steps are taken to prevent them, and of course it is then too late to save the tree or the parts of it that may have been injured. The efforts of growers, therefore, should be largely toward keeping the trees in such condition that the injuries may be prevented. The means of preventing summer desiccation, while simple in themselves, are not always easily carried out. In

cases where the injury results from imperfect root action owing to soil conditions, the latter may be changed by drainage, by cultivation, and in other ways by which more air is given to the roots. If the soil is too dry, as is often the case, its water-holding capacity may be improved by proper cultivation, by the addition of organic matter or humus, by mulching, etc. Top-pruning in dry seasons will often check the excessive demand for water and thus prevent injuries to the remainder of the tree. At present there seems to be no practical way of preventing the sudden damage which may be done by hot winds, except by copious watering of the soil, and even this may not always prevent serious injury, owing to the rapid evaporation at such times.

In the matter of preventing the winter "blighting," or drying out, of evergreens, every effort should be made to keep the roots in such condition that they can respond when a demand for water is made upon them. It is evident that if the soil is well dried out when winter sets in injury will result whenever the conditions already described prevail. When practicable, therefore, liberal applications of water to the soil may enable the trees to successfully pass through winters which, if such precautions were not taken, might prove injurious. Liberal mulching with straw or manure may also prove beneficial both as a conservator of the moisture and as a means of preventing the ground from freezing too deep and hard.

The most trying time for the trees is when they are young and small, that is, before the roots have extended very deep into the soil. At very little expense, however, such trees may be protected from both wind and sun by straw.

EXCESS OF ATMOSPHERIC MOISTURE.

During periods of long-continued rains or fog, evaporation from the leaves of trees is slow, and as a result the entire plant becomes charged with water. One of the results of this is an unusual mechanical stimulation of growth, and this growth is increased by changes in the cell contents, which give the cell in question an abnormal attractive power for water. Under these conditions nutrition is interfered with and the growth produced is thin-walled, unhealthy, easily dried up, and a ready prey for insects and fungi. Older parts of the plant are affected by these conditions in various ways, one being the production of little warts and swellings by the abnormal growth of cells, as described above. These may appear on leaves or stems, the tissues of which still possess some power of growth.

It often happens that leaves in the diseased condition described become water-logged in spots. This is especially common where two leaves are stuck together with a film of water, instances of which have been observed this year on the Norway, the hard, and the soft maples, as well as on various other trees and shrubs. The close

contact of the water with the cells of the leaf is very favorable to its absorption. Wet, translucent spots appear, especially around any little injury like the puncture of an insect or tear in the leaf surface. The presence of this water between these cells cuts off their supply of oxygen, and consequently they soon die and turn brown. The same trouble occurs when the leaf surface remains wet for twenty-four to forty-eight hours, even though not stuck to another leaf. The conditions about Washington, D. C., for example, have been unusually favorable to this trouble during the present season. In early spring vegetation was at first a little retarded by cool weather, but this was suddenly followed by good growing weather, during which the leaves of most trees and shrubs, especially those of Norway maples, pushed out with great rapidity. This latter period was followed by one quite dry and warm, during which red spiders increased to unusual numbers, particularly on the lower and more protected leaves of the crown. After this came a period of several days of rainy weather, and many of the spiders were washed off, but the leaves where they had been working became water-logged, as described elsewhere. The Norway maples and horse-chestnuts suffered most, the leaves of these trees in many cases appearing to have been scorched by fire.

Preventive measures.—Water logging and other injuries resulting from an excess of moisture in the air are not easily prevented; in fact, it is questionable whether anything practical can be done in such cases. However, trees can be made much less liable to such trouble by proper care in planting, feeding, etc. As already described, such trees as Norway maple and horse-chestnut, which are peculiarly susceptible to injuries of this kind, require special care, and it is a question whether it would not be best in the end to discard them entirely where the conditions are such as to make it almost impossible to keep them in health.

LOW TEMPERATURES.

The injuries from freezing are closely related to those brought on by desiccation. In fact, freezing of the tissues is a drying out of the water which they contain. If the tissues are dried beyond the point where they are able to again take up water, they are killed.

In a state of maturity and rest most of our trees and shrubs indigenous to regions subject to frosts stand freezing without the slightest injury, provided they do not thaw out too rapidly. In case of plants introduced from warmer climates, however, all degrees of ability to withstand cold are to be found, some being killed by the slightest frost, while others appear to adapt themselves readily to the changed conditions and withstand quite severe freezing. The fact that trees, especially exotics, growing in wet situations are more easily injured by cold than those growing in drier places, is probably because the former do not mature their growth, while the latter do to a great

extent. This is true also as regards the more succulent parts of plants, which are notably more subject to frost injury than the drier portions. Smooth-barked trees sometimes have their trunks and larger branches injured on the southwest side during winter, the injuries being characterized by the death of large patches of bark. During the latter part of winter and early spring, when there are periods of several days of warm weather, the cambium on the south side of the trunk and larger limbs is stimulated to premature activity. If the warm spell is followed by cold, freezing weather, these partially active areas will be killed, after which they gradually dry out, the bark, young wood cells, and cambium shrinking. After a time the bark separates from the wood and finally splits. This may not occur until pretty well into the summer months, and may not then be evident except upon close examination. During rains these portions become water-soaked, various ferment and decay-producing fungi gain entrance, and the rotting of that part of the trunk begins, extending rapidly from year to year, until the tree either blows over or is killed.

Cracks occur in a great variety of trees during very cold spells, especially when the fall of temperature is very sudden. It is a well-known fact that trees shrink under the influence of intense cold in the same way that felled timber does in drying. This shrinkage is due to the withdrawal of water from the cell walls, in the first case by freezing and in the second by evaporation. The extent of shrinkage is dependent upon the amount of water withdrawn. The cell walls of the outer new wood usually contain more water than do the walls of the heartwood. The outer wood will shrink in drying more than will the inner wood and will therefore split. The chance of splitting is greater when the outer-wood layers freeze before the inner ones, as they do during a sudden fall of temperature. This is Hartig's explanation of frost cracks and the one which has the most experimental evidence in its favor. Other explanations have been given, but it will be unnecessary to discuss them here. The cracks usually close up again during warm weather and ultimately heal over, doing little damage to the trees from the standpoint of this article.

Preventive measures.—The injuries to the trunks and branches by alternate freezing and thawing and the diseases resulting from them may be prevented by shading the parts exposed to the sun by means of a board set up on the south side of the tree, or, as is sometimes done, by screening the parts with straw, burlap, building paper, or other material which may be easily fastened to the trunk and branches. When once injuries of this kind have been produced, the dead areas should be cut out down to the healthy wood and the wound thus made covered with coal tar, varnish, or "hard oil."[1]

[1] Yearbook of the U. S. Department of Agriculture for 1895, pp. 257–300.

INJURIOUS GASES IN THE AIR.

In the vicinity of manufacturing establishments and often in cities and villages where large quantities of bituminous coal are used, vegetation, especially trees and other woody plants, are frequently seriously injured by the fumes which are thrown off into the atmosphere. Smelting works, fertilizing manufactories, brick kilns where soft coal is used, and similar establishments are the principal agencies involved. Frequently the injuries may be limited to a small area immediately adjacent to the factory or other place from which the fumes are given off. Again, the effects of gases may be seen for several miles, usually extending farthest in the direction of the prevailing winds. The effects of such gases on the trees are various, and it is often difficult to distinguish the injuries produced in this way from those resulting from purely climatic causes. From the evidence at hand it appears that the chief injury in such cases is due to sulphurous and hydrochloric acids, acting singly or in combination. The effects of these poisons are shown by the leaves turning reddish brown in spots or along the edges and eventually drying up entirely. The injuries are cumulative, certain branches of the trees being killed each year, while the others may make a feeble, struggling growth, owing to the cutting off of the food supply through the injuries to the leaves.

Preventive measures.—The question of remedying or preventing such evils is an important one and may often involve complicated legal questions. It may happen that the establishment of a factory in a certain neighborhood will result in much injury to farmers in the immediate vicinity by destroying their trees and crops. All the evidence goes to show that little can be done toward mitigating the trouble in the way of special apparatus for collecting the gases, high chimneys, etc. The question therefore resolves itself into one respecting the rights of the farmer on the one hand and the factory owners on the other. These matters, however, are beyond the province of this article.

FUNGOUS DISEASES.

All portions of the tree are subject to the attacks of fungi—minute parasitic plants, whose vegetative parts, known as mycelium, penetrate the tissues and by their action on them cause the various forms of blight, rot, etc. The fungi are rapidly propagated by means of spores and also in other ways, which do not concern us here. There is a very close relation between these organisms and the various other factors, such as the condition of the air, soil, etc., already discussed. In other words, the growth and development of the fungous parasites are intimately related to the condition of the host, which is in turn, as we have already seen, materially affected by the weather and by the soil. There are many fungi which under ordinary conditions could

never injure a tree, and yet if by some chance a favorable opportunity is offered they may prove quite destructive. (Fig. 54.) For example, a limb may be blown or cut off, hail may make a bruise, or in other ways wounds may be produced, and in these the spores of certain fungi may lodge and germinate and start decay that could not have been produced in any other way. Trees may succumb to the attacks of fungi only in certain stages of growth. Thus, young conifers are seldom affected by the disease known as canker, because any wound made in the trunk or branches is quickly covered with a coating of resin, which prevents the spores of the canker fungus from developing. When the trees get to be quite old, however, the wounds are not covered with resin and the spores of the canker fungus fall in these places, germinate, and spread into the surrounding tissue, and the tree is killed. On the other hand, the young, tender, rapidly growing tissues are more susceptible to the attacks of certain fungi than those older and better matured. With these introductory remarks, we may now pass to some of the diseases in detail.

FIG. 54.—Trunk of maple showing spread of fungous mycelium.

ROOT DISEASES.

In considering any case where fungi are found attacking the roots the importance of the previous effects of soil conditions must not be overlooked. An injury or a weakened condition produced by any of the means already pointed out may permit the entrance and development of some disease-producing fungus which might not otherwise gain entrance or find suitable conditions for development. On the other hand, there are fungi which, while they are better able to develop under these conditions, are nevertheless able to gain entrance into and kill what appear to be perfectly healthy roots.

SOUTHERN ROOT ROT.—This disease, which is produced by a fungus known as *Ozonium auricomum*, attacks a great variety of trees and other plants, including the elm, basswood, oak, cottonwood, mesquite, china tree, mulberry, etc. It also attacks cotton and the sweet potato—in fact, no plant appears to escape except the plum and some closely allied groups.

The disease first becomes apparent by the sudden wilting of the leaves, and soon the death of the tree follows. Examination of the tap-root and many of the other roots shows them to be dead and partly rotten, and thus unable to furnish the top with water or food. Trees growing in well-drained and well-aerated soils are seldom attacked, while those in soils very retentive of moisture are the first to succumb. The disease is confined largely to the Southern and Southwestern States, and is especially bad in wet seasons and where excessive amounts of water are used in irrigation. If the roots are examined closely, a whitish or usually yellowish-brown growth of loosely interwoven, hair-like threads will be seen on the surface and in the decaying tissues. These are not confined to decaying parts, but attack apparently healthy roots. Once inside, the fungus spreads rapidly through the cortex and wood, killing the cells and causing their decay. Only the mycelium, or plant body, is known, and this is reproduced from branches or pieces which may be broken or washed off. It has been observed growing in decaying vegetable material taken from the side of an irrigating ditch which furnished water for pears, cottonwood, alfalfa, and other plants dying from the disease. It is probable, therefore, that it may sometimes be distributed in this way. It spreads along roots and decaying material from plant to plant through the soil, and its distribution may also be hastened by tools used in cultivation.

Treatment.—It is seldom that a plant once attacked can be saved, as the trouble is not apparent until the root system is nearly destroyed. If there is any reason to fear this disease, trees should not be set on recently cleared land until the roots of the original vegetation have rotted and the soil is cleared of sticks, limbs, etc. If the trouble appears, the diseased trees should be removed, with as much of the root system as possible, and the roots burned; or it is still better to cut the tree down, leaving a stump 1 or 2 feet high, and then remove the earth about the roots and allow them to dry out. When dry enough the stump should be burned in its original position. Most of the fungus will in this way be burned and that in the neighboring soil killed. Every precaution should be taken to keep the soil well drained, well aerated, and free from weeds.

Honey mushroom (*Agaricus melleus*).—Another form of root rot is produced by the mycelium of the honey Agaric, or mushroom. The general appearance of the diseased plant is much the same as when attacked by the Southern root rot. Young trees may be killed within a year, but older ones show a weakened, stunted growth, and finally, after several years, dry up suddenly and die when a hot, dry spell comes on. Upon examination the bark at the base of the trunk and on the larger roots will be found to be dead. If a portion of it is removed, a white, leathery growth will be seen between the bark and the wood and between the different layers of bark. It may often be taken out in large sheets of varying thickness. The same will be found between the cortex and wood of the roots. On the outside of

the roots and in the surrounding earth dark-brown strands, varying in thickness from one twenty-fifth to one-twelfth of an inch, will be found. These may in many cases be traced to the white mycelium between the bark and wood. It is simply the mycelium growing in a different form, as it is not subjected to pressure between the bark and wood. These Rhizomorphs, as they are called, spread a few inches under the surface of the ground from tree to tree, and thus large areas may become diseased from a single center. In the autumn, from the base of the diseased tree and from exposed roots and Rhizomorphs, the fruiting bodies of this fungus develop. They are yellowish-brown, and are from 3 to 8 inches high and 2 to 4 inches across the top.

Treatment.—When once a tree is attacked by the fungus, there is no hope of saving it. If the tree is one of a group, it should be isolated by digging a ditch around it. The ditch should be dug deep and wide enough to get beyond the point where the brown strands of the fungus have reached. This precaution will be necessary only with the pines and allied trees, as others are not usually attacked unless first injured.

POLYPORUS VERSICOLOR.—There is good evidence that this fungus, which is a very common one, may produce root rot in many trees. It is probable, however, that such trees have been previously weakened, thus giving the fungus an opportunity to get in. When it occurs on the side of a stump or root, it forms a thin, rigid, shell-shaped growth, extending out at right angles to the surface. Usually many grow together, more or less united to each other at the back. The individual shells vary in size from one-half inch to 2 inches or more in diameter. The concave surface is always down and is made up of a layer of very small pores, in which the spores are produced. This porous surface is usually of a whitish-yellow color. The upper surface is shining, smooth, and velvety, marked with various dull-colored zones. (Fig. 55.)

The mycelium forms a white, felt-like covering on the roots, penetrating and causing the decay of the bark and wood. The first indication of the disease is in the decreased production or stunted growth of the wood and a tendency to overproduction of fruit. Examination of the roots of such trees reveals the white felted fungous strands, which continue to increase in abundance until the roots are nearly all rotted off. It is usually several years from the time a tree is first attacked until its death.

The mycelium spreads from tree to tree along decaying roots, so that in the course of years the trees over large areas are destroyed. Healthy, vigorous trees, in good soil, are much less liable to succumb than those growing under less favorable conditions. Trees planted in soil which has been recently cleared are most liable to attack, first, because the fungus is abundant in the decaying roots, and, second, for the reason that after a few years the nitrogen becomes greatly decreased, as explained elsewhere. The trees which have up to this

time been highly fed and growing vigorously are checked by the decrease of soil food. If this is not at once remedied by fertilization

FIG. 55.—Root-rot fungus (*Polyporus versicolor*).

and cultivation of the soil, the fungus may gain a foothold and the tree is doomed.

Treatment.—In all cases the rapid changes in soil conditions which follow clearing should be guarded against by not planting until these changes have taken place and until the roots of the original vegetation have rotted and proper soil conditions have been established. If injuries occur on the larger roots or the base of the trunk, the places should be cleaned and coated with pitch or coal tar. Burning the stumps and roots of diseased trees where they stand is advisable if the conditions are favorable for the spread of the fungus. In the early stages of the disease the tree may often be saved and enabled to outgrow the trouble by removing the earth from the base of the trunk and larger roots, clearing them as thoroughly as possible of diseased tissue, and applying coal tar to the wounds.

DISEASES OF THE TRUNK AND BRANCHES.

RED ROT OF OAK (*Polyporus sulphureus*).—This disease is most common in oak, but it is also found in the chestnut, poplar, cherry, and willow. Hartig describes it as parasitic also in locust, alder, walnut, and pear. As a parasite it gains entrance to the body of the tree through some wound. The mycelium then spreads through the wood, causing it to dry, shrink, crack, and turn reddish brown. In the cracks the mycelium forms large sheets or felted masses, as in the case of the red rot of the fir and pine. The inside of a trunk may become completely rotten in a few years from this cause. Whenever any wound permits the mycelium of the fungus to come to the surface, a large group of fruits are produced, extending out from the tree like brackets. The under surface is made up of a layer of thin-walled pores, whitish at first, then sulphur-yellow. The top is a whitish-yellow. The brackets are irregular in shape and size and are usually all grown together in an inseparable mass, which is usually from 6 to 20 inches or more across and from 2 to 4 inches thick. (Fig. 56.)

FIG. 56.—Fungus causing red rot of oak.

Treatment.—As the fungus can not gain entrance except through a wound, it may be readily guarded against by properly caring for wounds, as suggested in other parts of this article.

WHITE ROT OF OAK.—This disease is produced by *Polyporus igniarius*, a common fungus, which sometimes attacks the oak, hickory,

willow, and other trees. The mycelium of the fungus grows through the wood, reducing it to a yellowish-white, spongy condition. The Polyporus itself develops on the surface of the bark or wood. It is at first spherical in shape, but later assumes the form of a hoof, with the flat side turned down.

Treatment.—The fungus seldom, if ever, attacks sound tissues, hence the proper care of wounds is all that is required to preserve trees from its attacks.

There are numerous other fungi closely related to those described which may produce various kinds of rots in growing trees. Nearly all these gain entrance through cuts and wounds, hence the necessity of properly caring for these, especially during summer, when parasitic enemies of all kinds are active.

MISCELLANEOUS FUNGOUS PARASITES OF THE STEMS AND BRANCHES.

The fungi described under the previous heads have for the most part prominent fruit forms. There is another group much less conspicuous, but which sometimes causes considerable injury. This group—the so-called black fungi (Pyrenomycetes)—usually appear as dark-colored pustules on the bark of the stems and branches. The injuries in most cases are local, but in many instances a stem or branch may be completely girdled, and of course serious results will then follow. One of the common members of the group is *Nectria cinnabarina* (fig. 57). It occurs on nearly all kinds of deciduous trees, attacking dead and wounded branches and occasionally wounded roots.

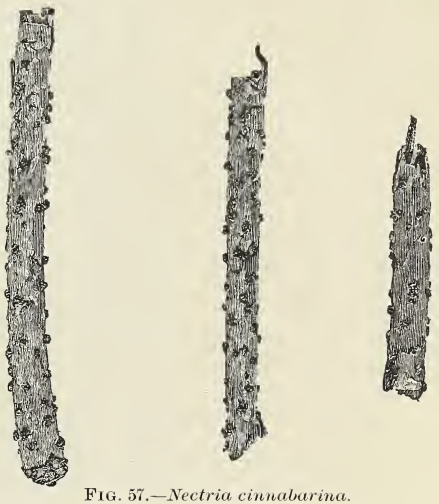

FIG. 57.—*Nectria cinnabarina.*

The fungus can not kill the living cambium and cortex, but grows rapidly through the wood, causing it to turn black and die, while the cambium and cortex are still sound. The wood in this condition, however, is unable to conduct water, so that the parts dependent on it dry up and die.

Another species, *Nectria ditissima*, with bright red fruiting warts, also attacks a great variety of deciduous plants. It spreads very slowly, however (not more than 1 or 2 inches in a year). The invaded tissue rots, but the surrounding healthy parts increase in growth, so that the part of the branch around the wound may become greatly distorted and swollen, producing what is ordinarily known as a canker spot. *Nectria cucurbitula* causes a similar canker disease of conifers, especially the spruce.

Various other canker-producing fungi attack trees, but it is not necessary to enter into detailed descriptions of them here.

Another class of fungi, belonging to the group of rusts, frequently cause considerable injury to trees, especially conifers. The Peridermiums are probably the most destructive of these parasites, attacking stems, branches, and leaves, and causing various knots, swellings, and blister-like patches.

Treatment.—From the nature of the fungi just considered, it will be seen that about the only means of checking them is to cut out and destroy the diseased parts as soon as possible. In many cases the injuries to trunks and branches are of such a nature that the diseased parts can be removed without trouble. This should be done, and all wounds thus made should be carefully covered with tar or grafting wax.

FUNGOUS DISEASES OF THE LEAVES.

In common with other plants, the leaves of shade and ornamental trees are subject to the attacks of many forms of fungi. Some of these produce local injuries, while others so affect the leaves as to cause them to fall prematurely. In all cases where the leaves are affected it will be seen that the more they are injured the more serious the results to the tree as a whole, for the leaves are the laboratories in which the food is prepared, and any check or injury to them results in a check to the growth of the tree. Probably the most common fungous parasites of the foliage of trees are those producing various kinds of spot diseases. Maples, chestnuts, oaks, basswoods, sycamores, poplars, and various other trees are more or less subject to the maladies in question. These spots are produced by certain species of fungi, which attack the tissues, and by their action first weaken and then destroy them. The spots vary in color, size, and shape, and can usually be distinguished from those brought on by sun scald and similar agencies only by microscopic studies.

Of the other diseases of the foliage, the powdery mildews and rusts are probably the most common. The former attack many trees and shrubs, producing a whitish, spider-web-like growth on the surface. A common example of this group of fungi is found in the mildew which occurs in late summer on the lilac. Maple leaves are also frequently attacked, and the same is true of the chestnut, willow, and other trees. The rusts are limited to a comparatively few groups of trees, among which may be mentioned the pines, poplars, and willows.

Treatment.—There is comparatively little that can be done toward checking these diseases. Spraying in many cases is not practicable on account of the size of the trees, and even if it were, it is questionable whether the injury resulting from the parasites is sufficient, except in some few cases, to pay for the trouble involved. As many of the fungi pass the winter either in or on the old leaves, burning these in the autumn may help materially in keeping the parasites in check. Careful attention to the needs of the trees in the matter of food and water will also go far toward freeing them from the attacks of such enemies as have been described.