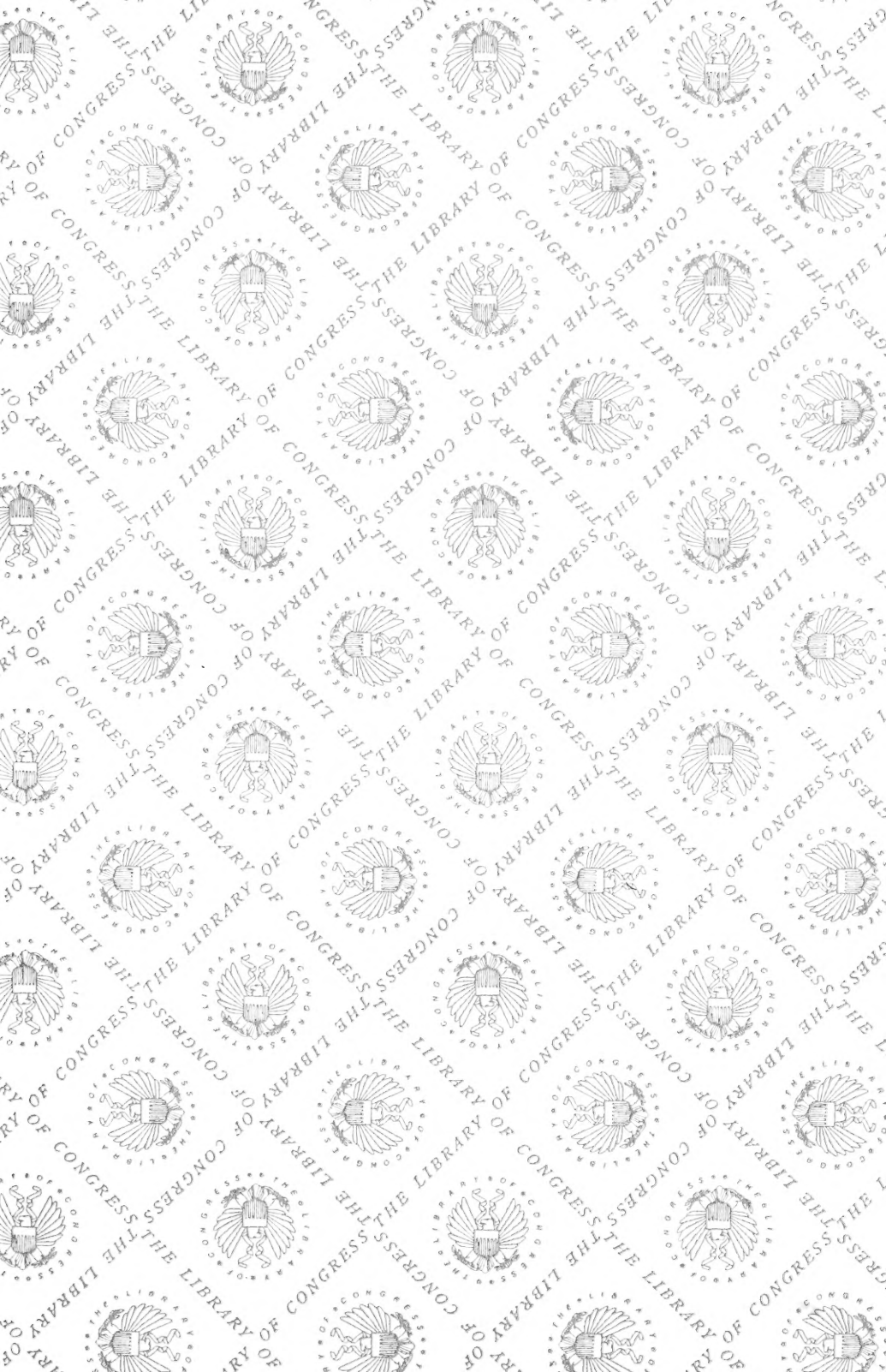
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Symptoms of Disease in Plants

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Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

President Mirabeau B. Lamar.

SYMPTOMS OF DISEASE IN PLANTS

It is highly important that all persons engaged in general farming, truck gardening, fruit raising, or floriculture should be able to recognize the presence of disease. In their mute way plants tell us when they are suffering from constitutional or contagious diseases if we are only able to interpret their language. It is evident that many people do not recognize the presence of diseases, for it is not an uncommon thing to receive replies like the following to the letters of inquiry that are sent out over the state: "There are no plant diseases present in our locality"; "All the crops in our region are free from diseases"; "No diseases in our country."

The diseases that affect plants may be divided into three different groups: first, those disturbances of nutrition which are due to unfavorable conditions in the environment of the plant, or to the conditions inherent in the plant itself; second. troubles due to the presence of parasitic plants, generally either bacteria or fungi, but sometimes to flowering plants which deform, stunt, or kill the affected plant by their presence; third, those caused by insect pests, which are in many cases very evident, and in other cases not easily detected. Many of these insect troubles are hardly to be classed as plant diseases, while many are as truly diseases as those produced by parasitic fungi. In the nature of the resulting symptoms, there are no sharp and fast lines that can be drawn between many insect and fungus troubles, and often a careful microscopic examination is necessary in order to diagnose the disease. The first thing of importance for the farmer is to detect the presence of the disease and then to endeavor to find out its cause, nature, and probable outcome and the treatment which should be employed, by consulting those who have made the subject a special study.

Before taking up the main part of this paper, which will deal principally with the symptoms of diseases produced by bacteria and fungi, brief mention may be made of a number of flowering plants which are parasitic upon other flowering plants.

The best example in this class is afforded by the various species of dodder (*Cuscuta*), twining vines, devoid of chlorophyll or leaf green and possessing only rudimentary leaves. Dodder twines around the stems of the host plants much as a morning-glory twines around its support. The dodder is devoid of chlorophyll and is not attached to the ground by roots, so that it must obtain all of its food by robbing the host upon which it is growing. It does this by sending its sucking organs or

haustoria into the stems around which it grows. One of our cultivated plants seriously infested with dodder is alfalfa. Seeds of four different species of dodder may be found in alfalfa seed, and several of the species

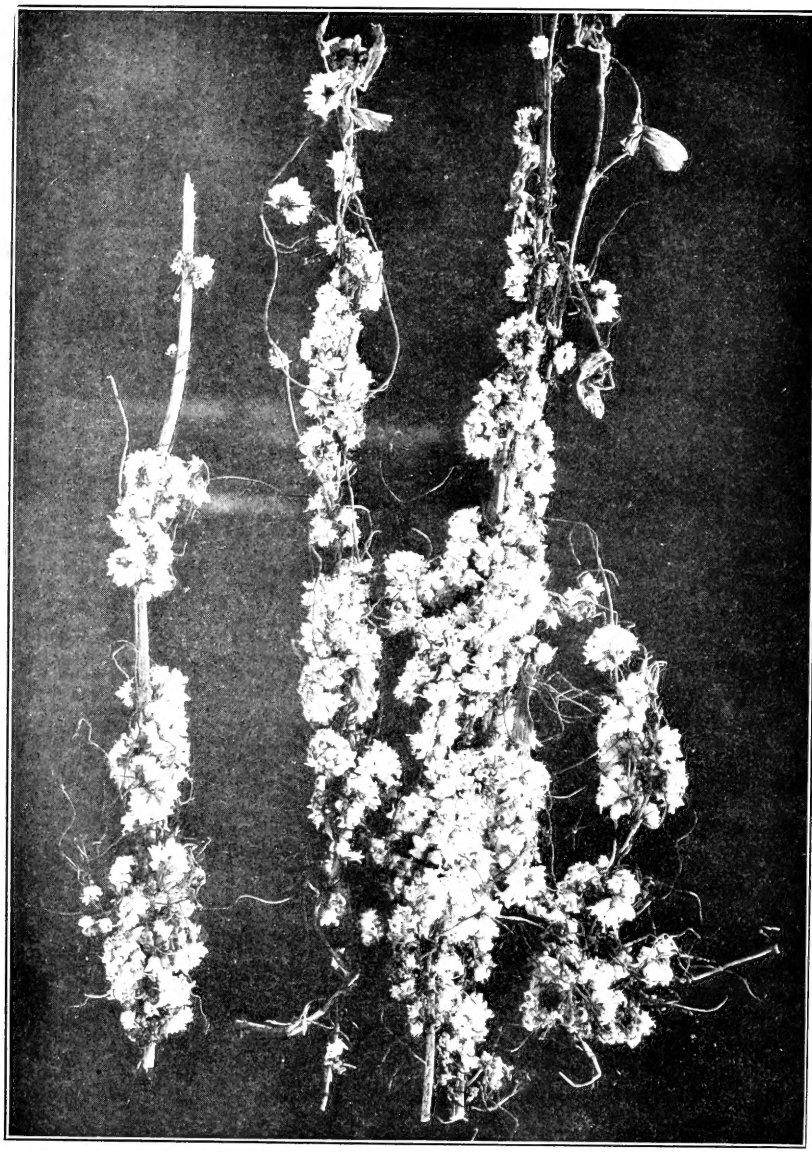


Fig. 1.—Dodder or "Love Vine," a serious parasite upon alfalfa. Original.

are reported as doing considerable harm in various parts of the alfalfa-growing territory. The dodder is a rampant grower, and soon kills

alfalfa by robbing it of food and smothering it with its dense growth of intertangling stems.

Many of our forest and shade trees are attacked by another type of parasite, the mistletoe (*Phoradendron sp.*). This is a parasite which possesses green coloring matter and is consequently able to supply a part of

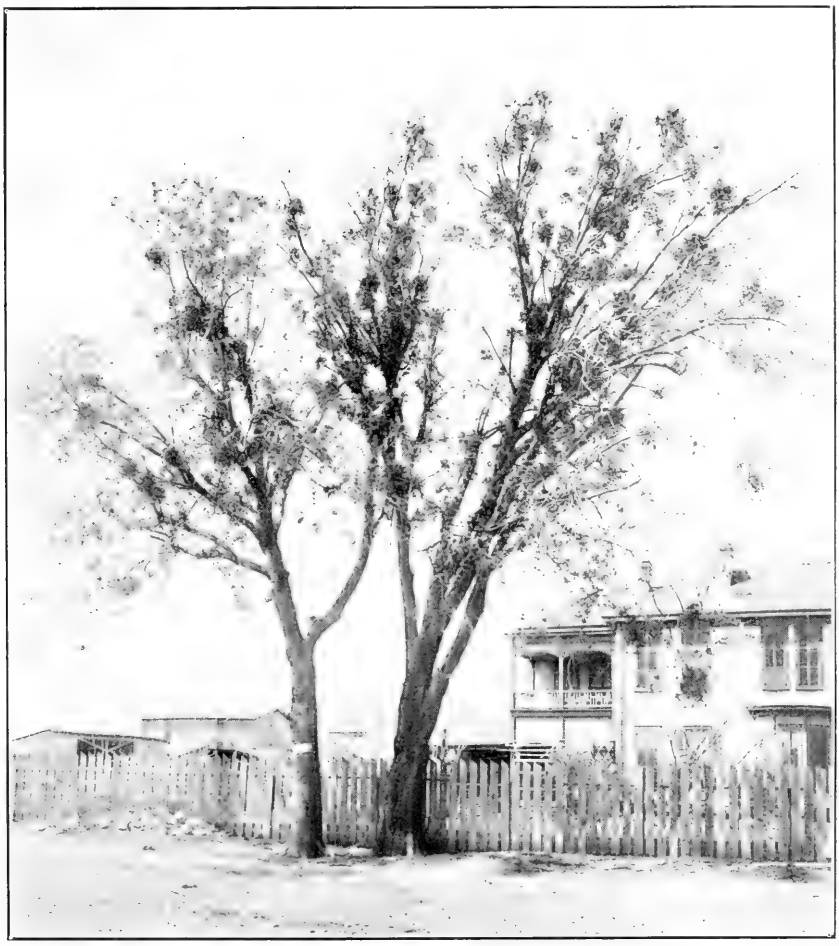


Fig. 2.—Trees badly infested with mistletoe (Phoradendron flavescens). Photograph in School of Botany collection.

its own food. The mistletoe does, however, stunt and deform the host plant on which it is living, the amount of injury depending upon the extent of the infection.

The distinction between true *parasites* and *epiphytes,* which merely find lodgment on the surface of the plant on which they are growing,

should be kept in mind, since several such plants are common in this region. The so-called "long moss" (*Dendropogon usneoides*) which grows upon various forest and shade trees is a familiar example of such an *epiphyte*. This plant is not a moss as most people suppose, but is a flowering plant, which merely finds lodgment upon the branches of trees

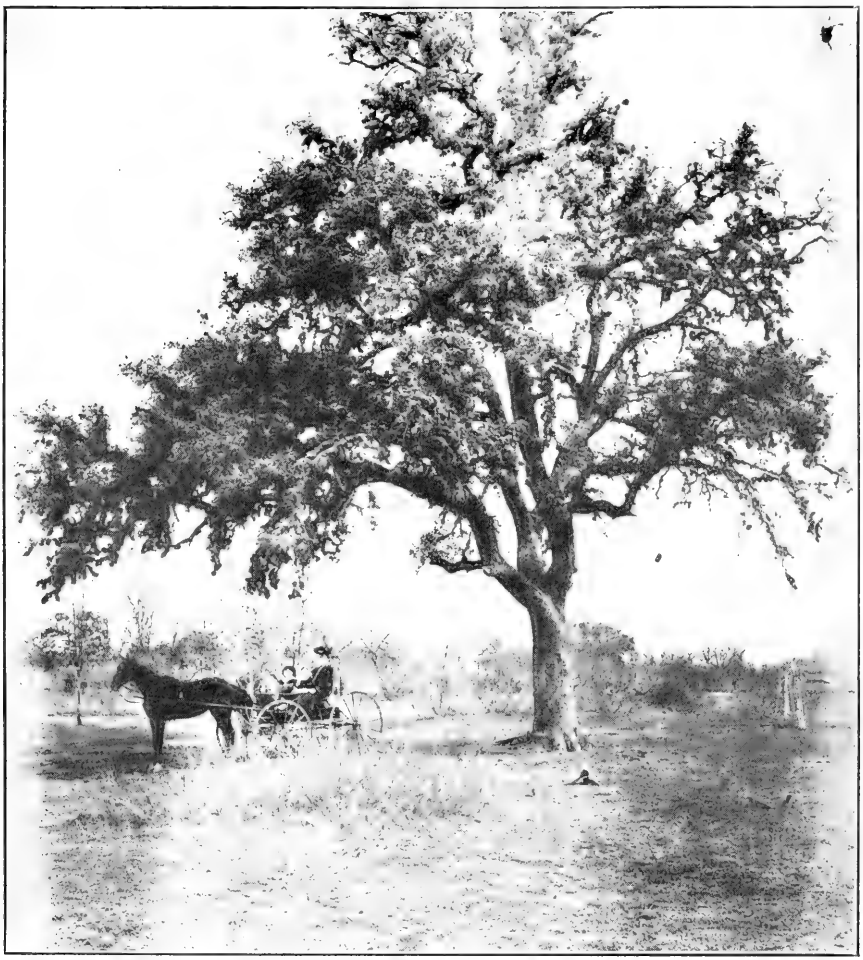


Fig. 3.—Tree completely covered with "Ball Moss" (Tillandsia recurvata). Photograph from School of Botany collection.

and does not rob them of any of their accumulated food material. The "short moss" or "ball moss" (*Tillandsia recurvata*) is equally familiar, and in this section of the state is more conspicuous upon park and shade trees occupying the higher locations, while the "long moss" is predominant on trees occupying the valleys. Both of these *epiphytes* probably

cause injury to the trees which harbor them, but this can only be the case when the "moss" becomes especially abundant. By crowding the foliage of the tree, checking the development of young shoots, and harboring insect pests, the "long moss" or "short moss" may be detrimental to the life of the trees upon which they are growing, but they should never be looked upon as parasites.

The following outline will give a survey of the principal symptoms of disease in plants, placing *most emphasis* on those diseases due to bacteria and fungi:

1. Discoloration or change of color from the normal.
   - (a) Pallor. Yellowish or white instead of the normal green.
   - (b) Colored spots or areas on leaves or stems.
     - Whitish or grey: mildews; white rusts, etc.
     - Yellow: many leaf spots.
     - Red or orange: rusts, leaf spots, etc.
     - Brown: many leaf spots.
     - Black: black rust, tar spots, etc.
     - Variegated: leaf spots, etc.
2. Shot-hole: perforation of leaves.
3. Wilting: "damping off," "wilt," etc.
4. Necrosis: death of parts, as leaves, twigs, stems, etc.
5. Reduction in size: dwarfing or atrophy.
6. Increase in size: hypertrophy.
7. Replacement of organs by a new structure.
8. Mummification.
9. Change of position.
10. Destruction of organs.
11. Excrescences and malformations.
    - Galls: pustules, tumors, corky outgrowths, crown galls, etc.
    - Cankers: malformations in the bark generally resulting in an open wound.
    - Punks or conchs and other fruits of fleshy fungi.
    - Witches' brooms.
    - Rosettes and hairy root.
12. Exudations.
    - Slime flux.
    - *Gummosis:* especially for stone fruits.
    - *Resinosis:* especially for coniferous trees.
13. Rotting:
    - Dry rot and soft rot: the "gangrene" of plant tissue.
      - Root rots: alfalfa, cotton, beets, cherry, etc., generally woody or fleshy roots.

Stem or trunk: dry rot of trees; rot of modified stems like rhizomes, bulbs, or tubers.

Buds.

Fruits: fleshy fruits of various kinds.

It is quite common to find the foliage of trees in the prairie regions showing a pronounced yellow cast instead of the normal green color. This yellowing is especially prominent in the regions where the soil is decidedly alkaline or where there is a seepage of ground water from high irrigation ditches to a lower level, or where both of these conditions prevail. The conspicuous sickly yellow corn plants that may be found in

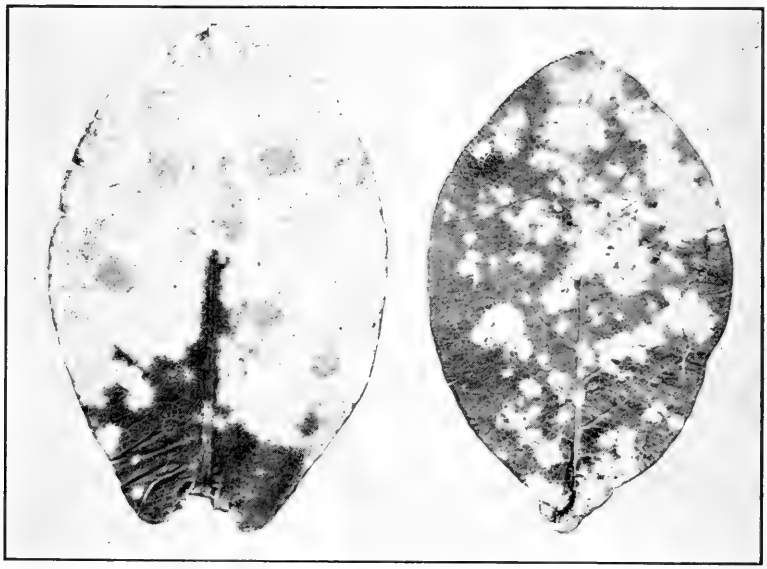


Fig. 4.—Powdery mildew (Microsphaera sp.) of the honeysuckle. The leaf nearly covered by the fungus shows groups of minute black bodies, the spore-fruits or perithecia. Original.

the early part of the season upon flooded fields or in water-logged soils is another example of this marked symptom of disease. The lack of sufficient iron in the soil will also cause a plant to pass into what is technically termed a *chlorotic* condition, that is, the leaf green or chlorophyll is either not developed at all or only to a slight extent. These chlorotic plants can often be restored to their normal condition by supplying them with iron. The occasional white plants that appear in corn fields are some of our plant "albinos," and are suffering from rather complex disturbances of their nutrition. Another physiological trouble, the "mosaic disease," common in the tomato and the tobacco plants, is

characterized by the mottled appearance of the leaves, or, in other words, the leaf is somewhat variegated with yellow and green.

When the leaf shows colored areas or spots that are more or less definite and circumscribed, and different from any normal coloration we may be fairly certain that it is suffering from either an insect or fungus disease, with the presumption in favor of the latter.

Fig. 5.—Crimson rambler rose showing powdery mildew (Sphaerotheca pannosa) on stem and leaves. The leaves are curled and reduced in size. Original.

White patches more or less definite or somewhat diffuse are generally due to either some of the "Powdery Mildews" or to the "Downy Mildews." We have a good illustration of this symptom in the powdery mildews of the apple, peach, cherry, grape, gooseberry, wheat and other grasses, the elm, catalpa, mesquite, the lilac, honeysuckle, crimson rambler and other roses, golden glow, etc. In all of these cases the fungus

that causes the disease lives on the surface of the host plant, or is what may be termed an external parasite. During the first part of the season the surface of the leaves or stems of the host plant is covered with an interlacing tangle of minute white fungus filaments, and the powdery appearance is due to the production of large numbers of minute repro-

Fig. 6.—Twig from a young cherry tree infected with powdery mildew. (Podosphaera oxycanthae). The mildew is very abundant on the under surface of the leaves and causes the leaf blades to roll. Original.

ductive bodies or spores, which become heaped up on the white patches. Later in the season many of these "Powdery Mildews" produce winter fruits, which show as small black bodies scattered over the white patches or grouped in special clusters. (Fig. 4.)

In some of the "Powdery Mildews" the presence of the fungous para-

site causes more or less discoloration of the affected leaves together with more or less curling or rolling. This is especially marked in the powdery mildew of the cherry. (Fig. 6.) In the powdery mildew of many roses, the leaves are curled and at the same time stunted or dwarfed in size.

In the downy mildew of the grape, which is an internal parasite, we often find the under side of the leaf covered with irregular whitish patches

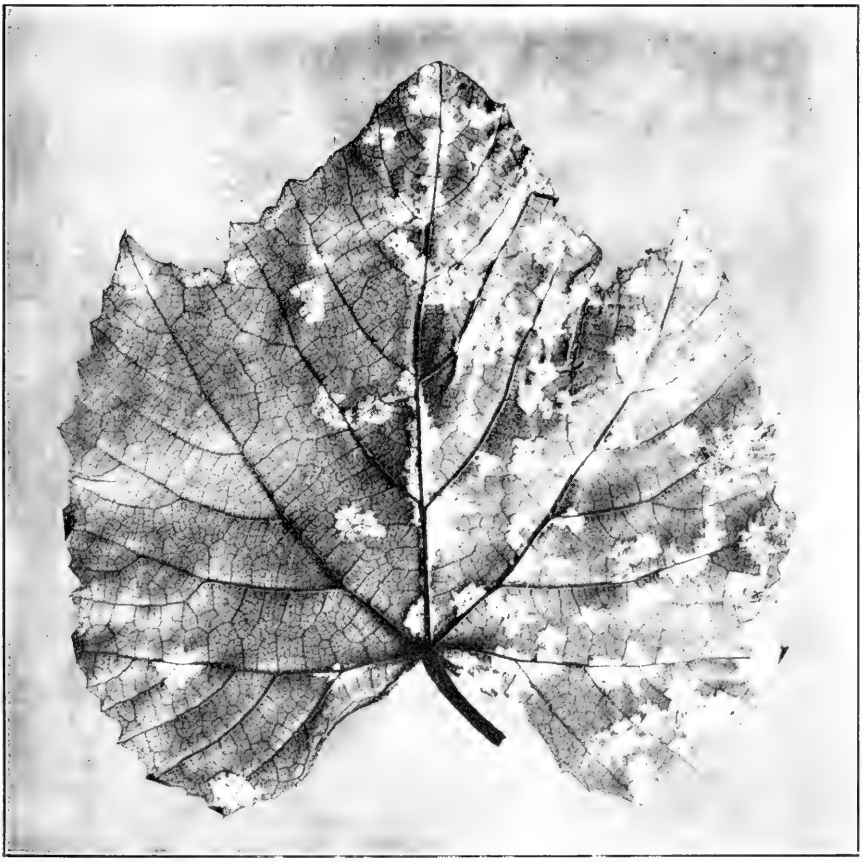


Fig. 7.—Leaf of grape vine showing the conspicuous patches of downy mildew (Peronospora viticola) upon the under surface. Original.

which are formed by the spore-producing parts of the fungus that emerge from the interior of the leaf. It may be mentioned in this connection that the upper side of the leaf, directly over these spots is at first a yellow color, but later changes to a dark brown. When the disease is very prevalent, the leaves may turn brown throughout, shrivel somewhat, and fall from the vines, or they may be cast while they are still more or less

mottled with green, yellow, and brown areas. Other downy mildews showing somewhat the same symptoms may be found on cucumbers, lettuce, spinach, and onion among garden vegetables, and upon some of our forage crops like millet, clover, and alfalfa.

In some diseases which are not due to "Powdery" or "Downy" mildews, the appearance of white patches upon the under surface of the leaves with yellow areas upon the opposing surface is characteristic. This is especially noticeable in a serious leaf-spot disease of the parsnip. (Fig. 8.)

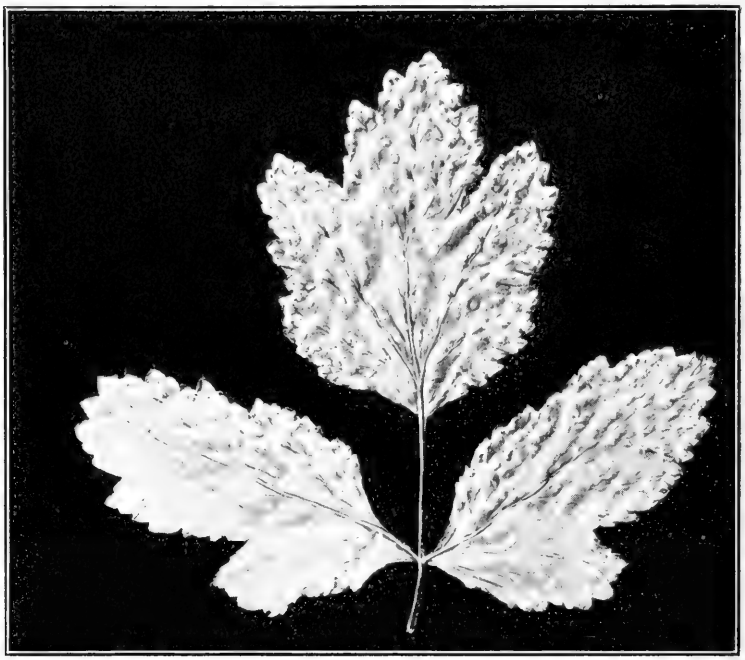


Fig. 8.—Portion of parsnip leaf affected by fungus (Cercosporella sp.), which produces conspicuous white spots upon the under surface. Original.

The "white rusts" generally show more definite whitish pustules which eventually rupture and allow the escape of the spores. The white rusts may be observed upon cress, the sweet potato, morning glory, turnips, radish, cabbage, horse-radish and related plants, and also upon the leaves of the oyster plant. The white rust of the oyster plant may be so severe as almost to kill the tops and thus greatly reduce the development of the roots.

In some diseases the affected spots are of a grayish color, either uniform throughout or with margin or center of a different color. In a leaf

disease of the elm, the leaf is covered with irregular grayish patches with dark or black, somewhat papillate centers, while parts of the same leaf may be brown and dead. In the leaf-spot of the common strawberry the

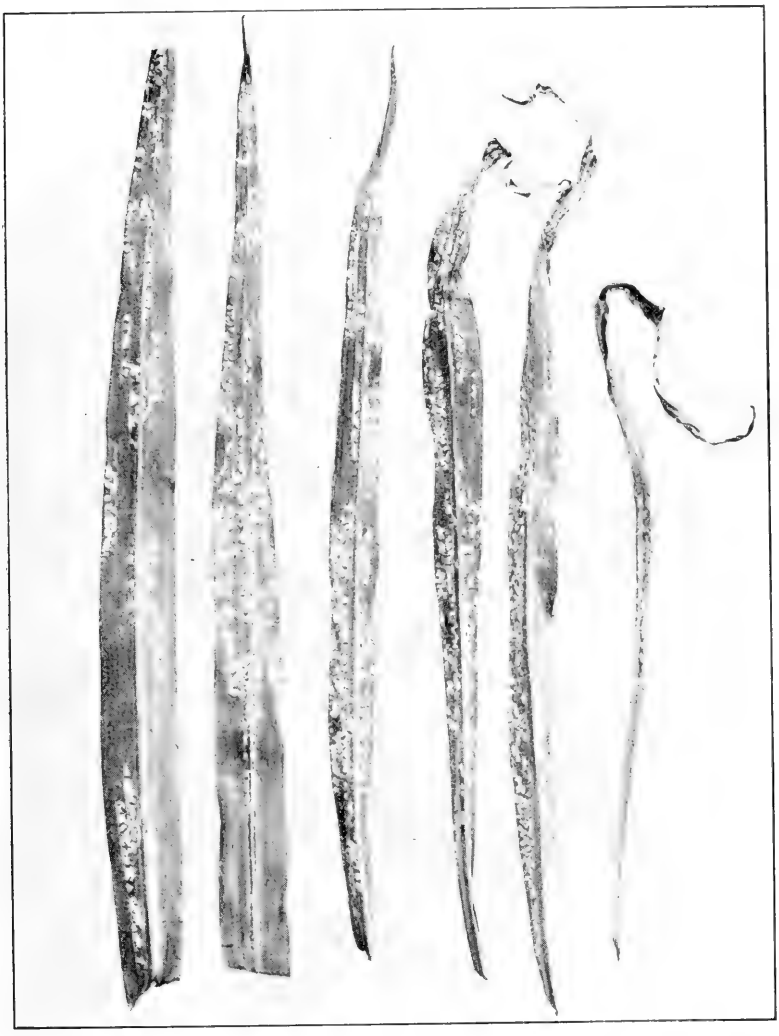


Fig. 9.—Leaves of oyster plant affected with white rust (Albugo tragopogonis). The tips of some of the leaves have turned brown and have begun to curl. Original.

fungus causes numerous circular grayish spots surrounded by quite definite purple borders. A disease of the prickly pear, called *anthracnose,* is not uncommon in the Southwest. Circular grayish, slightly sunken,

patches, one-half inch or more in diameter, with dark or black centers, are quite characteristic of this disease. In an *anthracnose* of the box, the mature spots are grayish, one-fourth to one-half inch or more in diameter, and surrounded by a narrow brown border, or show more or less concentric zonation. In the early stages of the disease the spots are yellow and turn gray with the development of the disease.

Many fungi that inhabit leaves have a localized effect and produce more

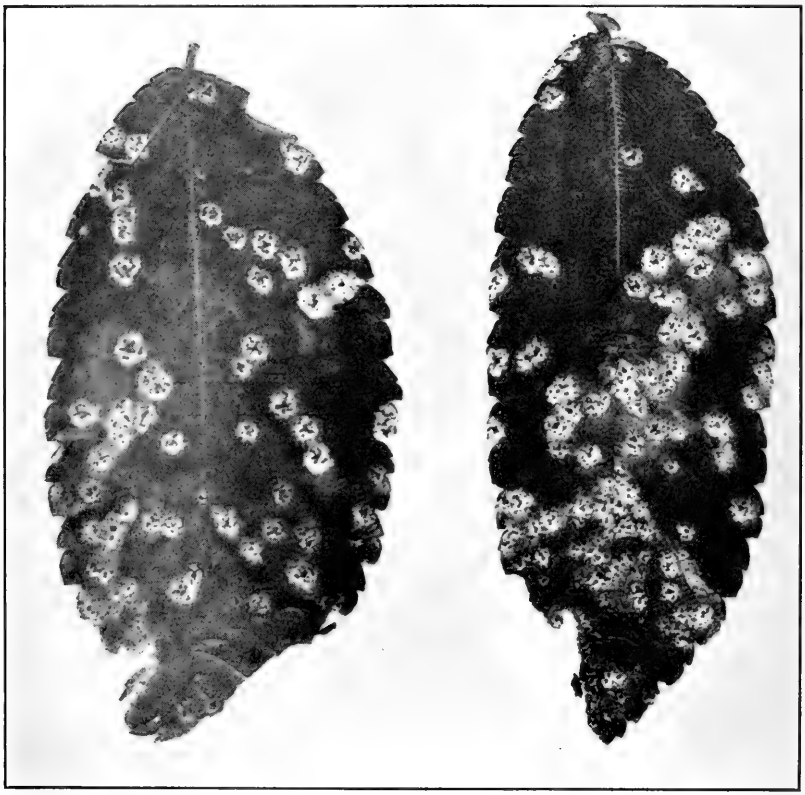


Fig. 10.—Leaves of the cork-winged elm showing abundant scab spots (Gnomonia ulmea). x 2. Original.

or less circular or slightly irregular spots of a marked yellow color. In such cases the disease is generally characterized as a "leaf-spot." Symptoms of this kind may be noted in the leaf-spots of the oak and violet, and in the *anthracnose* of cucumbers and melons. Sometimes the change in color becomes more general, and the whole leaf turns yellow and falls from the tree as in the early summer stage of apple scab.

Another marked symptom of disease is the occurrence of red or orange

spots or pustules. The "Rusts" of our cereals and other crops received their name from the fact that in the early stage of the attack, reddish or brownish spore-producing pustules give the stems or leaves a rusty appearance. Sometimes these rust spots may be few in number, at other times so numerous that almost the entire surface of leaf or stem is covered, and thus the vigor and productiveness of the crop is seriously impaired. In all of our cereal rusts, black pustules appear on leaves and stems as a later growth. The red pustules always predominate and give character to the disease in the "orange rust" of wheat and the "crowned rust" of oats, while the black stage or black rust is the conspicuous stage

Fig. 11.—A segment of prickly pear showing several anthracnose spots (Gloeosporium sp.). Photograph by F. D. Heald and F. A. Wolf.

in the "stem rust" of wheat. Some of the other cultivated plants affected by rusts are the clovers and alfalfa, cotton, beans and peas, beets, asparagus, plum, peach, cherry, fig, cottonwood and willow, roses, carnations and chrysanthemums. The cluster-cup stage of many of the rusts produce fairly large, well-defined orange-colored spots in many cases. This symptom is well illustrated in the well-known "cedar rust" of apple leaves, and in the cluster-cup stage of the "crowned rust" of oats on the leaves of the buckthorn. Deeper red or even purple colored spots or extended areas indicate the presence of a leaf parasite in many cases. This is often noticed in the early stages of the shot-hole diseases of the cherry

or the peach, and is especially characteristic in the bacterial blight of sorghum, Johnson grass, or Kaffir corn. In the last-mentioned case the dark red or purple patches are generally somewhat elongated and more or less irregular. The leaves of dandelion affected by rust generally show a reddening of the whole leaf, while the under sides of blue-grass leaves affected with the powdery mildew frequently show spots of a deep purple color.

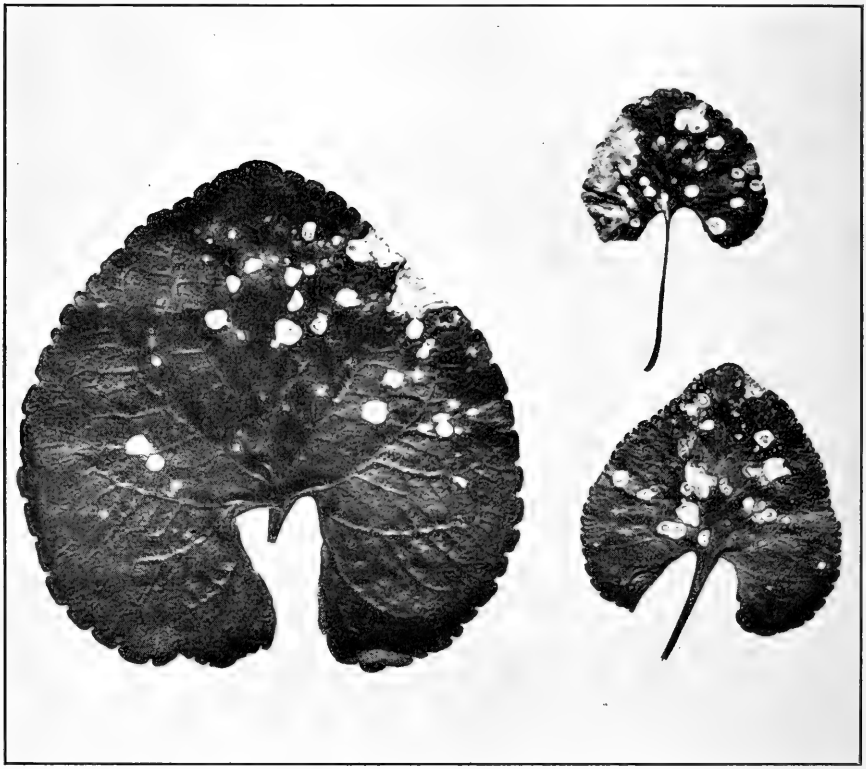


Fig. 12.—Violet leaves affected with leaf-spot (Alternaria violae). Photograph by F. D. Heald and F. A. Wolf.

The pods of beans frequently become conspicuously "rusted." The presence of rust-colored, sunken patches, either scattered or very abundant, is characteristic of the so-called *anthracnose* of beans. The disease is especially noticeable on the wax-podded varieties, and the majority of farmers and gardeners speak of the trouble as "rust," although the fungus which causes the trouble does not belong the the true rust fungi.

Definite brown areas, either small or somewhat extended, are quite characteristic of spot diseases of either leaves or fruits. The leaf-spots

of apple, pear, and plum are common diseases in this and adjoining states. As a result of these troubles, the leaves begin to drop and a pre-

Fig. 13.—Leaves of Johnson grass affected with bacteriosis (Bacillus sorghi). Photograph by F. A. Wolf.

mature defoliation is the result, thus sending the tree into winter rest with an insufficient supply of reserve food for the growth of the follow-

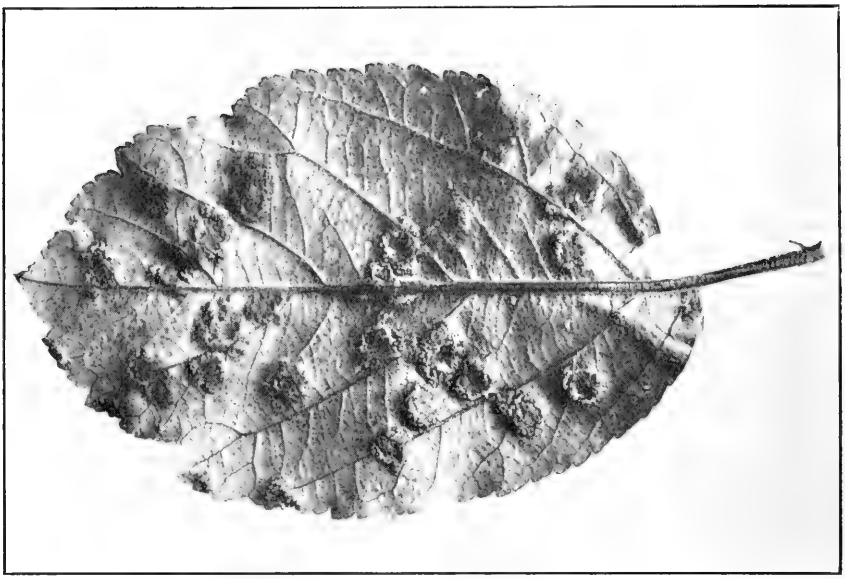


Fig. 14.—Apple leaf from the under surface showing conspicuous patches of rust (Gymnosporangium juniperi-virginianae). Original.

Fig. 15.—Pods of black wax beans affected with anthracnose, commonly called "rust" (Colletotrichum lindemuthianum). Original.

ing season. As a result of the leaf-spot, Ben Davis trees are often defoliated when other varieties are in full foliage. The leaves of tomato plants often show an abundance of small brown spots. As these spots become more plentiful, the intervening areas turn yellowish, the leaf begins to shrivel and curl and finally drops off. Many gardeners do not recognize this behavior of tomato leaves as a symptom of disease, since it is of such common occurrence. The early blight of potatoes is characterized by brownish spots on the leaves that often show more or less of a concentric zonation. As the fungus spreads, the spots may coalesce,

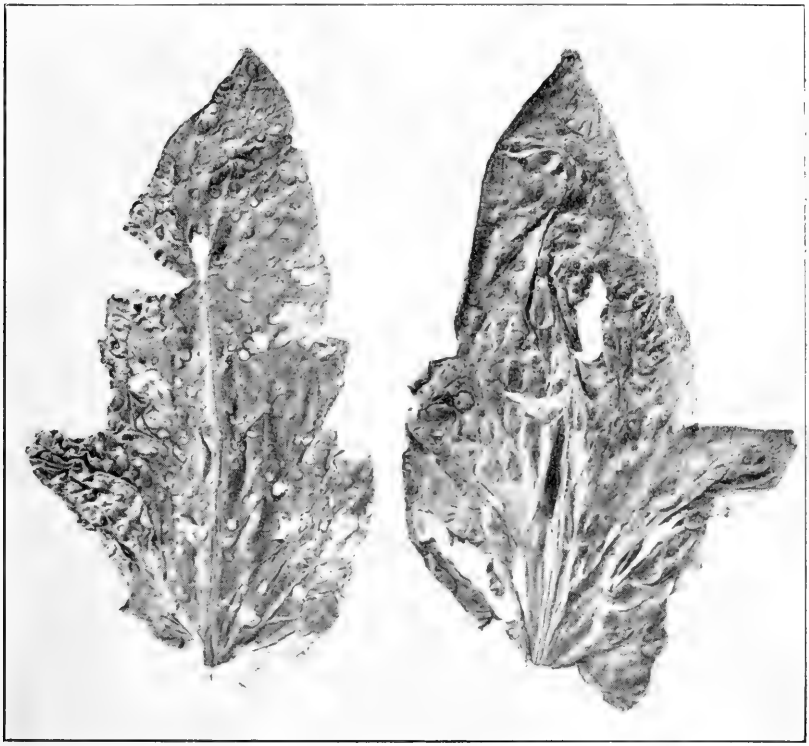


Fig. 16.—Leaflets from tomato plants affected with leaf-spot (Septoria lycopersici). Original.

and thus the entire leaf will be killed. Sometimes the brownish color is not confined to definite spots, but is more general as in the diffuse form of apple-scab, which shows upon either the under or upper surface of the leaves.

The definite scab spots on the fruits or leaves of apples, pears, or peaches may be gray, brown, dark olive green, or even almost black. More or less deep cracks or fissures often appear in later stages of scab. In the *Ascochyta* blight of the pea, the leaves and pods become covered with

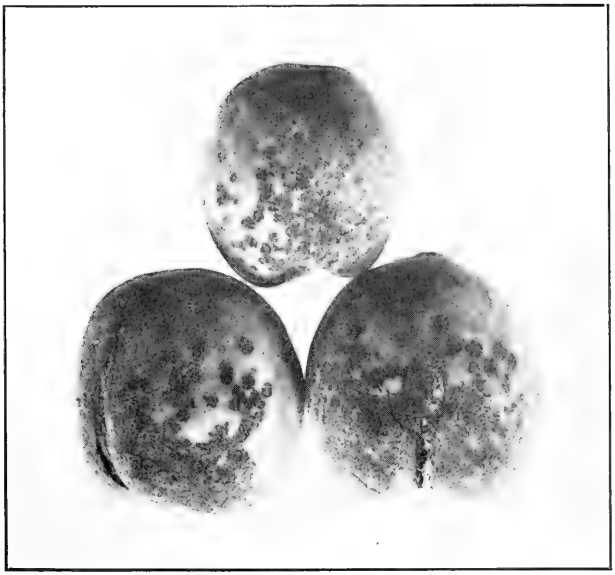


Fig. 17.—Peaches showing abundant brown spots sometimes called "peach freckles" (Cladosporium carpophilum). Original.

more or less circular brown areas of dead tissue. The brown patches may coalesce to form extended dead patches on either leaves or pods. A careful examination of the patches will show minute black specks, the fruits of the fungus, scattered over the middle of the spots. Many other

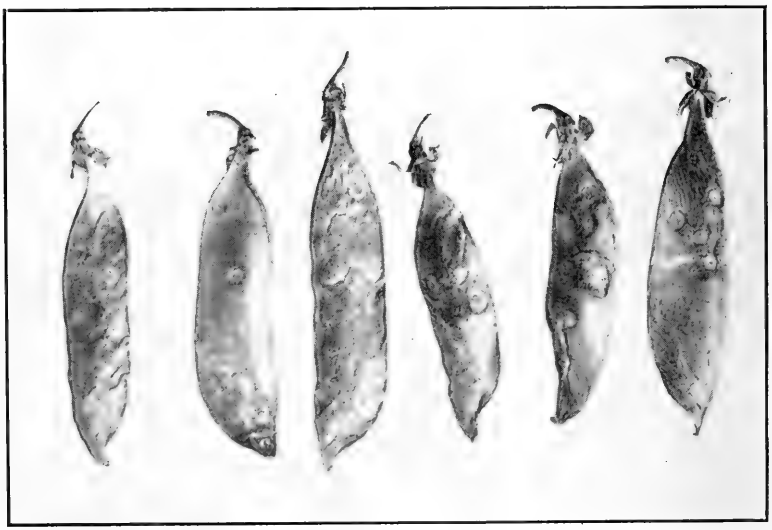


Fig. 18.—Pods of peas showing different degrees of abundance of the Ascochyta blight (Ascochyta pisi). Original.

Fig. 19.—Leaf-spot of rhubarb, showing shot-hole effect and concentric zonation. Original.

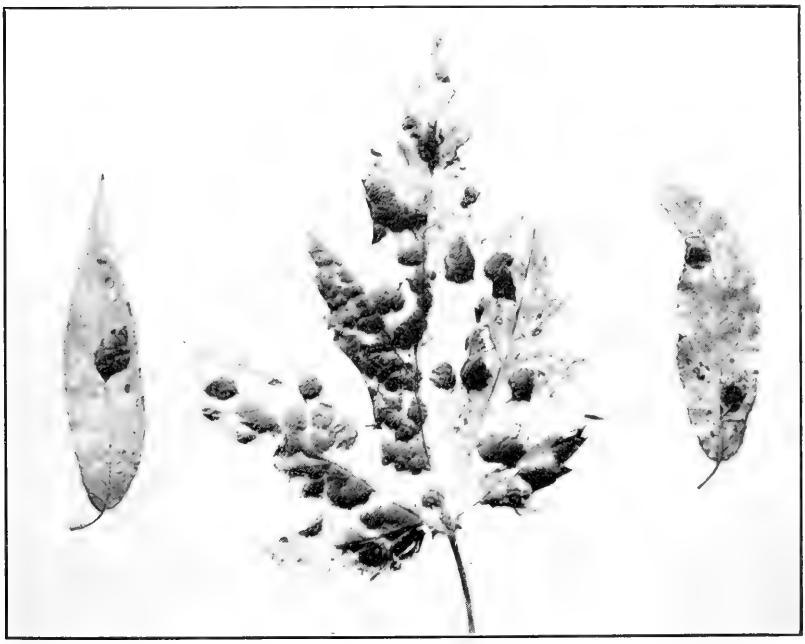


Fig. 20.—Tar-spot (Rhytisma acerina) of willow and silver maple. Original.

examples of a somewhat similar character may be mentioned, as the leaf-spots of beets, watermelon, maple, mulberry, chrysanthemum, rose, rhubarb, etc. Other troubles, such as spray injury, or sun-scald, may be indicated by brownish discolorations, but in the majority of cases this symptom indicates a fungus disease.

The appearance of black spots upon stems or foliage is not an uncommon symptom of disease. One of the most striking cases of this character is in the so-called "tar-spots" of our maples, willows, and live oaks. Leaves affected by this trouble show large, irregular blotches of blackened tissue—in fact, they look almost as if they had been spattered with drops of tar. When these spots become abundant, the intervening tissue of the

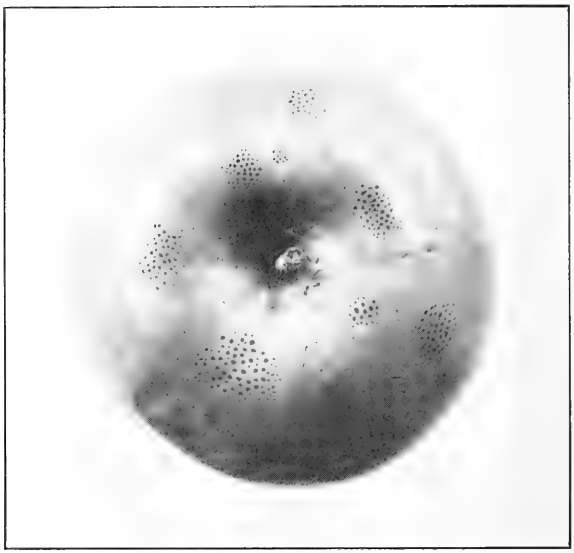


Fig 21.—Fly-speck fungus (Leptothyrium pomi) on an apple. Original.

leaf turns yellow, and the leaves are dropped quite early. In severe epidemics considerable injury may result from these "tar-spots." In all of our cereal rusts, the winter stage is indicated by either small black covered pustules or by elongated black streaks having a somewhat powdery appearance. The winter spore pustules of the orange leaf rust of wheat are small and covered, and are generally confined to either leaf blade or sheath, while the winter spore pustules in the stem rust of wheat, rye, or oats are in the form of elongated naked streaks, which are more numerous on the stem than on any other parts of the plant. In a leaf disease of the honey locust, the leaflets often show numerous small black spots on the under side; in many cases these black spots become so numerous

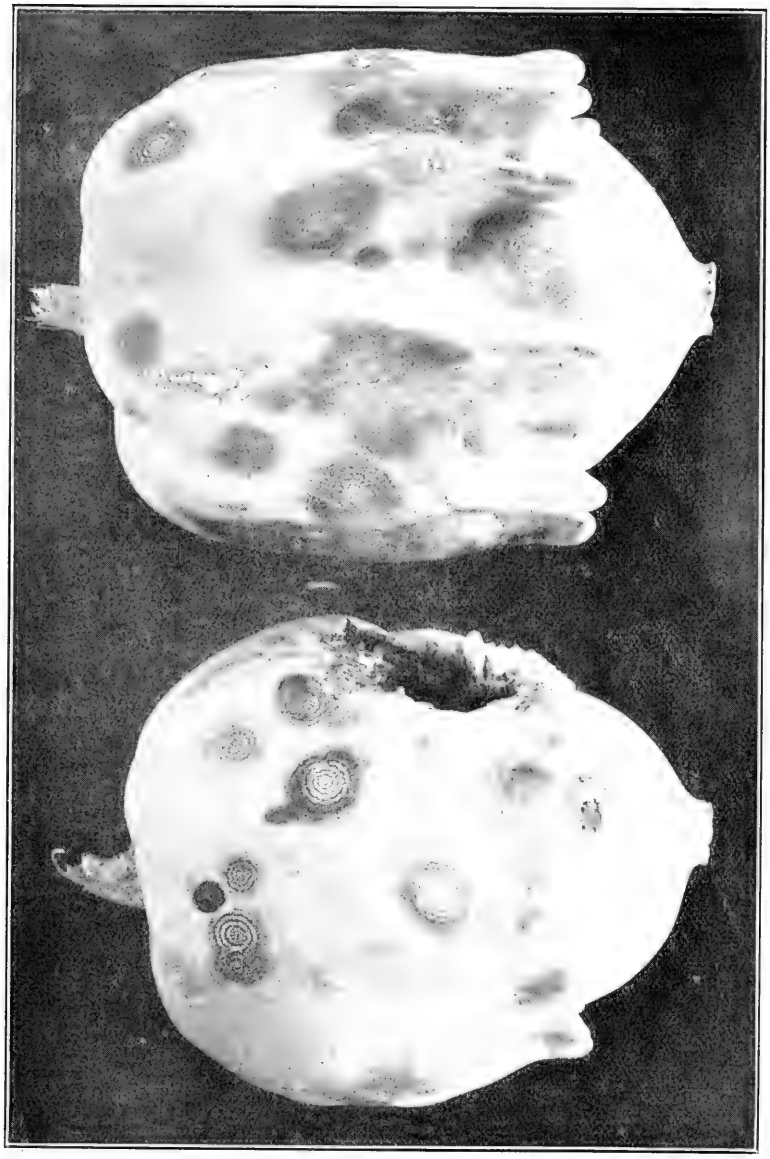


Fig. 22.—Anthracnose (Colletotrichum sp.). of Filipino squash. Original.

that they coalesce and cover the entire surface of the leaflet, hence the common name "black leaf" disease. Another fungus trouble that is quite common in orchards is the so-called "fly-speck" fungus of the apple. Fruits attacked by this fungus show small clusters of circular black spots which on account of their characteristic appearance have suggested the

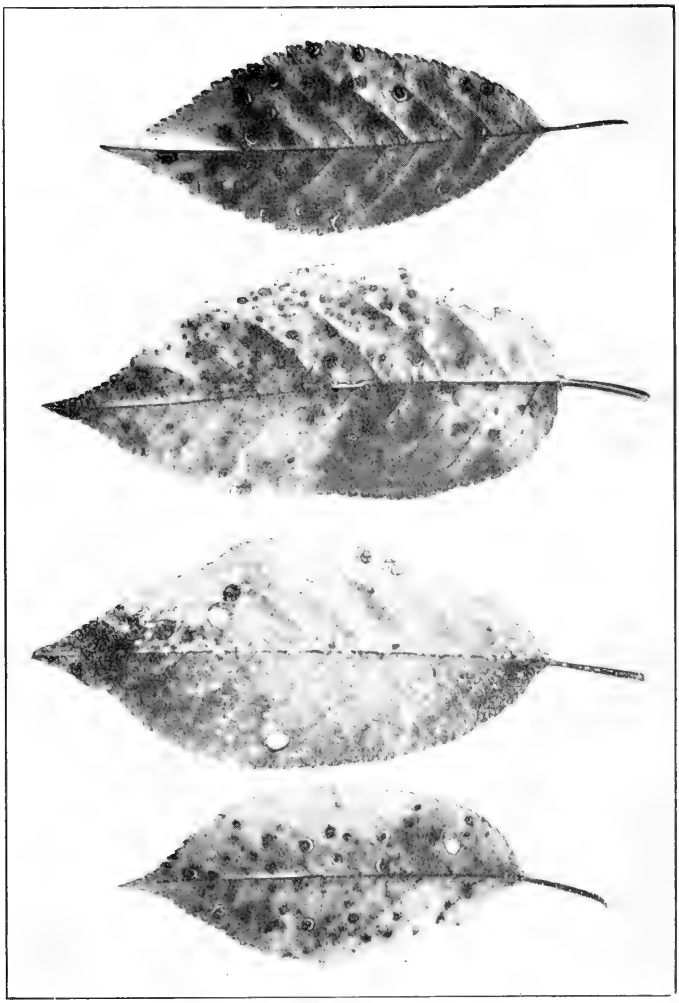


Fig. 23.—Shot-hole (Cylindrosporium padi) of the cherry. Original.

common name. This fungus is more common and evident on the yellow skinned varieties. The "sooty" fungus produces larger, and more diffuse, smoky brown, or almost black, irregular patches upon the epidermis of apples.

In some of the anthracnoses the affected areas are circular in outline

and show concentric circles of minute black spots, the fruiting pustules of the fungus which causes the trouble. It has been shown that this zonation is due to the alternation of light and darkness. The anthracnose of the box and of some of the squashes and gourds, and also the anthracnose of the tomato afford excellent examples of this symptom.

Leaves which show circular or sometimes irregular perforations have probably been affected by some fungus parasite. In many cases leaves so affected will show brown spots of dead tissue which have not yet dropped out. Several diseases have been called "shot-hole" diseases on account of this peculiar effect upon the foliage. Notable among these troubles is the shot-hole disease of the cherry and plum. This is some-

Fig. 24.—Shot-hole disease (Cercospora sp.) of the Virginia creeper. Original.

times called "rust" by orchardists, but the true cherry rust is an entirely different disease. Nearly all of the English Morello cherry trees in some sections of the country have been killed during the past few years by this so-called "shot-hole" disease. In this disease of the cherry the leaf tissue adjacent to the affected spots frequently shows a marked purple coloration, while at certain stages in the development of the disease the intervening areas may be distinctly yellow in color. Sometimes the leaves fall from the tree before the perforations are complete, while in other cases the leaves still hanging upon the tree will be found to contain numerous perforations.

Both *Cercospora* and *Phyllosticta* spots of the Virginia Creeper fre-

quently show a marked shot-hole effect. The perforations are so numerous that in some cases they might easily be mistaken for the work of insects. Such a *Cercospora* spot is shown in the accompanying illustration. (Fig. 24.)

A sudden wilting of a plant which can not be explained by dry conditions of soil or air is often due to the attack of a parasite. Both seedlings and mature plants exhibit this symptom, and the loss which is occasioned by diseases having this attendant symptom is often enormous. In a

Fig. 25.—Shot-hole disease (Cylindrosporium padi) of the plum. Original.

seedling the disease in which this symptom is prominent is often called "damping off." The young plant drops dead, as it were, for a fungus parasite has entered the stem at about the ground level, and has struck a vital blow, interrupting essential physiological functions. A disease of cotton seedlings of this nature is prevalent throughout the South, and is known to the planters as "sore-shin." A disease of the squash and related forms called "wilt" is not uncommon. In this trouble the parasite enters the stem and grows rampantly in the water vessels or ducts

until they are completely plugged, and the supply of water to the foliage is interrupted. Often the first indication of the presence of this disease is the sudden wilting of the plant, no previous warning symptom having made its appearance.

Fig. 26.—"Damping off" or "sore-shin" of cotton seedlings (Rhizoctonia sp.). Each seedling shows a dead brown area at the ground level. Photograph by F. A. Wolf.

In some diseases, the death of parts of the plant, as leaves, twigs, stems, flowers, etc., is the first symptom that is observed. In the fire-blight of pears and apples the young terminal twigs with their leaves and

flowers are killed and even large branches are involved and succumb. The leaves turn brown and dry up while still hanging upon the tree, and the twig will be found to be dead down to a certain point, which marks the advance of the bacterium which is the cause of the disease. In this disease small gummy drops which consist of myriads of these bacteria, often ooze out from the dead bark. Sometimes the blossoms of plums turn brown and die prematurely as if blasted by frost or fire. This

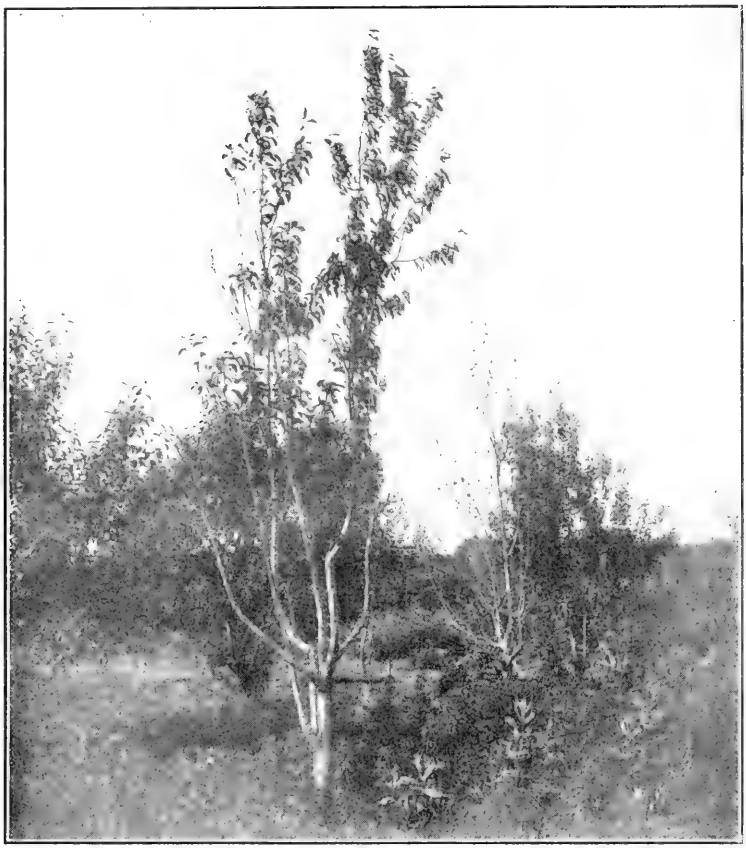


Fig. 27.—Pear trees killed by "fire blight." Tree in the foreground covered with dead leaves, brown and curled. Photograph by F. A. Wolf.

blighting of the blossoms is due to a different organism, the brown rot fungus, which causes the rotting of peaches, plums, cherries, and sometimes apples later in the season.

In many diseases a more or less marked reduction in size, a dwarfing or atrophy of the whole plant or some of its organs, is evident. A crippled and deformed individual or a poorly developed organ, with impoverished nutrition, is the result in many cases. The dwarfing or re-

Fig. 28.—Normal apple and series affected with scab (Venturia inaequalis) showing spotting, deforming and reduction in size of fruit. Original.

duction in size of apples by attacks of scab is often prominent. Many apples seriously affected do not reach over one-fourth the natural size, while others are gnarly and deformed, owing to localized atrophy of the tissues of the fruit. The same may be said of apples affected by "cedar-rust," although perhaps the effect is not as striking as in apple scab.

Fig. 29.—Normal apple and series showing effect of apple rust (Gymnosporangium juniperi-virginianae). Original.

In a disease of the peach, known as "little peach," a marked reduction in size of the fruit is one of the attendant and characteristic symptoms. Every farmer is familiar with the shrunken and shriveled appearance of wheat from badly rusted fields. The energy of the plant is sapped by the rust fungus, and as a result the grains are poorly developed, lessening

Fig. 30.—Twigs and leaves of ash showing the effect of the cluster-cup stage of rust (Puccinia fraxinata). Original.

the yield and quality of the crop. The dwarfing of stem, leaves, roots, flowers, or flower parts, or even the complete arrest of seed development, is often the result of the inroads of some parasitic fungus.

While a large number of fungi produce more or less extensive atrophy or dwarfing of parts of their host, others cause abnormal enlargements of organs or parts of organs. The so-called "plum pockets" or "fools" is a

Fig. 31.—Wheat grass affected with ergot (Claviceps purpurea). Original.

striking illustration of hypertrophy. In this disease the outer layers of the fruit become thick and fleshy, while the pit remains undeveloped, causing the modified fruit to be hollow, hence the other common name of "bladder plums" which is sometimes employed. The flower parts of the radish and related plants are frequently enlarged and deformed as a result of the attacks of white rust, while the catkins of some of our trees

show striking modifications of size and color due to the stimulating effect of their fungus guests. The twigs, petioles, and leaves of our common ash often show orange-colored enlargements due to the growth of the cluster-cup stage of a rust fungus. The vegetative parts of plants, as stems, leaves, and roots, often exhibit peculiar enlargements, but most of these may be considered under the head of excrescences and malformations.

It sometimes happens that a parasitic fungus produces a new structure which takes the place of some normal organs of the plant, as in the so-

Fig. 32.—Rye grass affected with ergot (Claviceps purpurea). Original.

called "ergots" of our wild and cultivated grasses and rye. These ergots are horny resting bodies or *sclerotia* of the fungus that occupy the same position as the kernel or seed, and appear only with the destruction of the seed-producing structure. These ergots not only affect the seed production of the host plant, but they contain poisonous principles which produce serious disease when ergot-infested hay is fed to cattle.

The production of "mummies" is another characteristic symptom of disease in fruit trees. Apples that are badly affected with either brown rot or black rot often dry up slowly and remain hanging on the tree over

winter in a more or less hard, shriveled condition. These mummies at the end of the winter period of rest may produce a crop of spores which will spread the disease. This spore-production may take place while the mummies are still hanging on the tree or on the fallen mummies. The formation of mummies is especially common in plums and peaches that are affected with the brown rot. It must be at once evident that mummies should be destroyed in order to prevent production of new crops of spores and thus to lessen the ravages of these rot-producing diseases in an orchard. The practice of allowing rotting plums or peaches to fall to the ground and remain beneath the tree should certainly be discouraged.

Change of position is a symptom of disease that is sometimes overlooked. This is well illustrated in some plants which are affected with

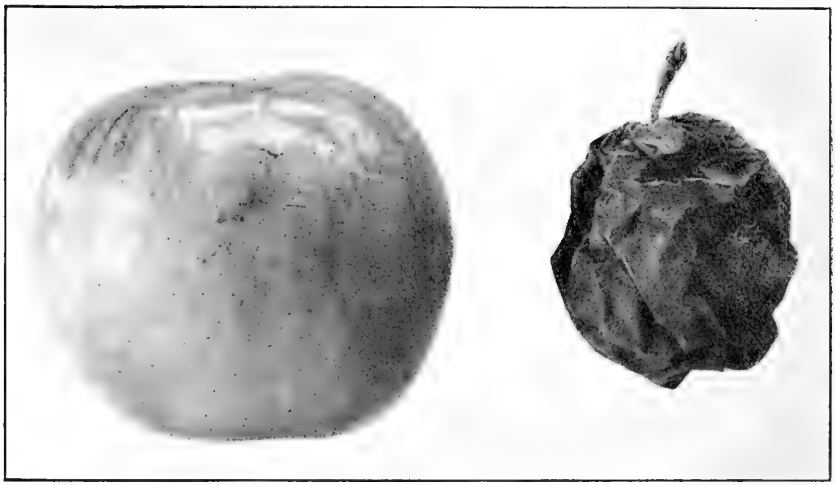


Fig. 33.—Normal apple and "mummy" produced by the black-rot fungus (Sphaeropsis malorum). Photograph by F. D. Heald and Leva Walker.

a rust fungus, in the cluster-cup stage. Some of the spurges which are normally more or less prostrate or creeping become erect when attacked by a fungus of the kind mentioned. The common garden weed known as "pusley" grows normally in a prostrate condition, but when it is attacked by the "white rust," many of the seriously affected branches become more or less erect or ascending. This same symptom is present in some tree diseases, in which normally horizontal limbs or branches become more or less erect.

As a result of the attacks of a fungus parasite a complete destruction of organs may result. This effect is well illustrated in the majority of our cereal smuts. In the loose smut of wheat, for example, the complete inflorescence is destroyed, the glumes and other flower parts being reduced to a powdery mass of black material, the smut spores, which

finally drop away, leaving nothing but the bare central axis of the head. The same effect with but little deviation may be noted in the naked and covered smuts of barley, and the loose smut of oats, while in the kernel smut of sorghum, the kernel smut of oats, and the bunt of wheat, it is

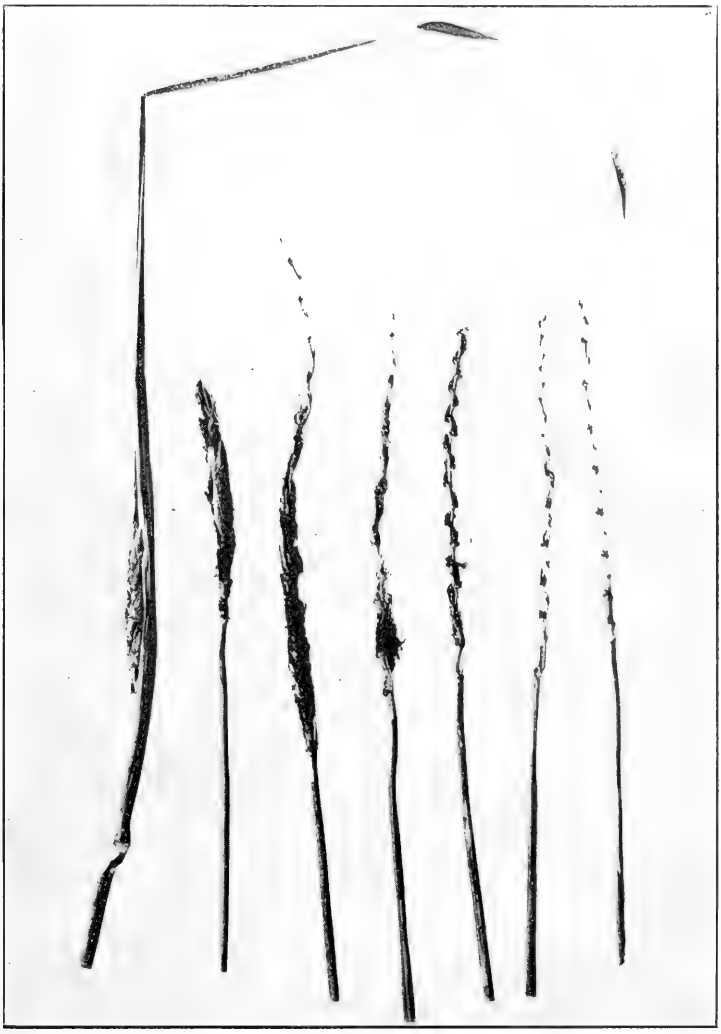


Fig. 34.—Winter barley affected with loose or naked smut (Ustilago nuda). Original.

the berry alone which is destroyed, the surrounding parts remaining intact. In the last mentioned cases the berry or "seed" may show an increase of size or a modification of form with the complete destruction of all its tissue except a surrounding membrane which serves to confine the

mass of smut spores. When the membrane is ruptured, the interior brown mass crumbles to powder, since it is simply a loose aggregate of spores which have been formed at the expense of embryo and endosperm. In sorghum affected with the kernel-smut each grain or kernel of the diseased head or inflorescence is destroyed and the whole head has a much more compact form than is characteristic for the normal inflorescence. Wheat fields in which bunt or stinking smut is present emit a characteristic odor, and an examination of affected heads will show that each

Fig. 35.—Winter barley affected with covered smut (Ustilago hordei).

smutted head has all of its "berries" destroyed, and further that all heads from a given "stool" or plant are invaded and destroyed if the fungus is present in any. Wheat from fields infested with bunt is often dark in color due to the immense numbers of spores lodged upon the surface of the kernels and especially collected in the "brush" or tuft of hairs at the distal ends of the berries. In many cases wheat is so seriously infected with bunt that the yield is enormously reduced and the market value of the actual yield materially decreased.

As a result of the stimulating effect of a fungus parasite, parts or organs of the host plant may exhibit variously formed excrescences or malformations. These malformations may be in the form of pustules or small blister-like elevations upon the surface of the leaf or stem, as in the "white rusts," or the blistered areas may be quite extensive and cause more or less deforming and rolling of the leaf as in peach "leaf-curl." Sometimes the abnormal formation is in the form of a smut

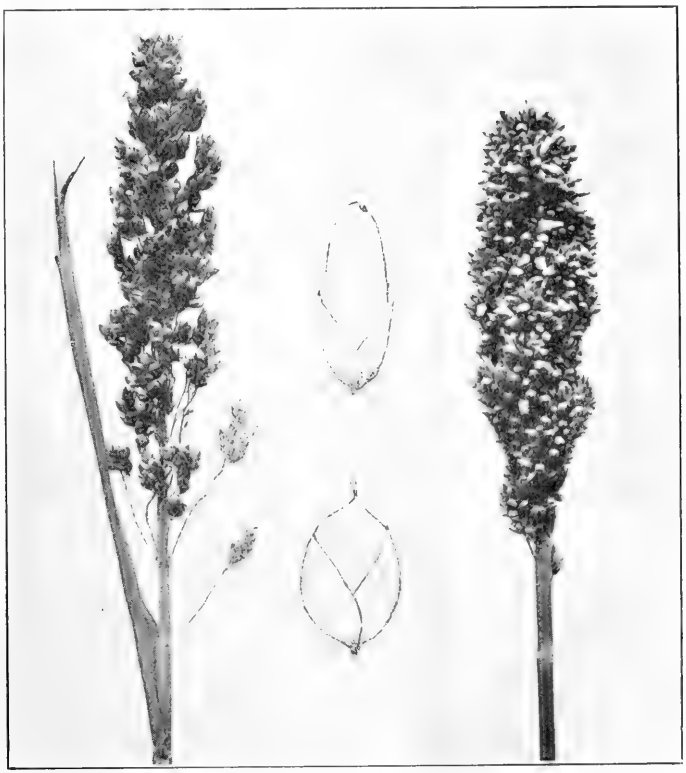


Fig. 36.—Normal and smutted heads of sorghum; normal kernel and smutted kernel (Sphacelotheca sorghi). Original.

mass or tumor which, when mature, is filled with a brown or black powder, the spores of the fungus. In the smutted corn plant these tumors may occur on any part of the plant, not a single aerial organ being exempt, although the majority of people think of corn smut as affecting only the ears or tassels. The head-smut of sorghum simulates corn smut somewhat in general external appearance, but in this case the whole inflorescence is destroyed by the time it emerges from the leaf sheath.

The so-called "cedar apple" is a good illustration of a fungus gall.

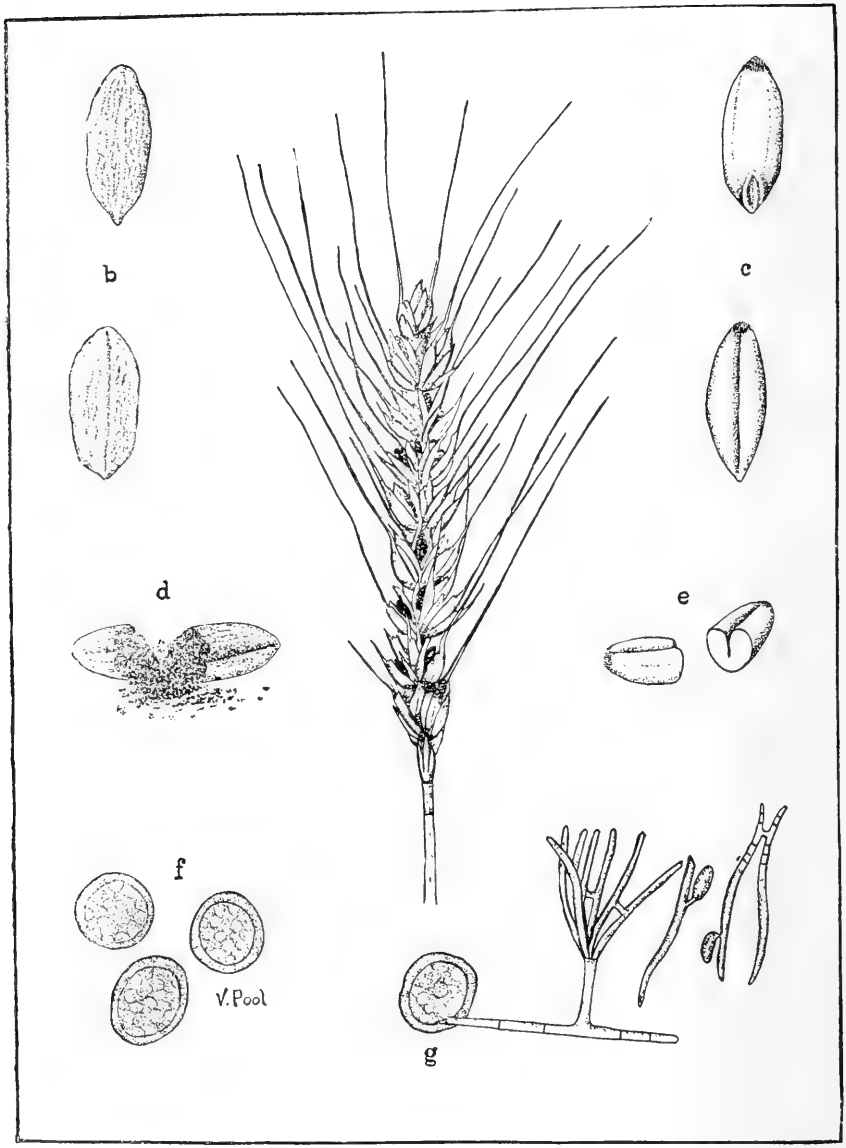


Fig. 37.—Bunt or stinking smut of wheat. (a) whole head affected with smut; (b) smutted grains; (c) normal grains; (d) smutted grain broken to show smut; (e) normal grain divided in the middle; (f) spores much enlarged; (g) germination of a spore. From a drawing by Venus W. Pool.

These brown cedar apples may be present on the cedar trees in large numbers in case of trees that stand adjacent to an apple orchard, and they may vary in size from about that of a radish seed to nearly two inches in diameter. Badly affected cedar trees may be so covered with these galls that many of the branches droop with the added weight like

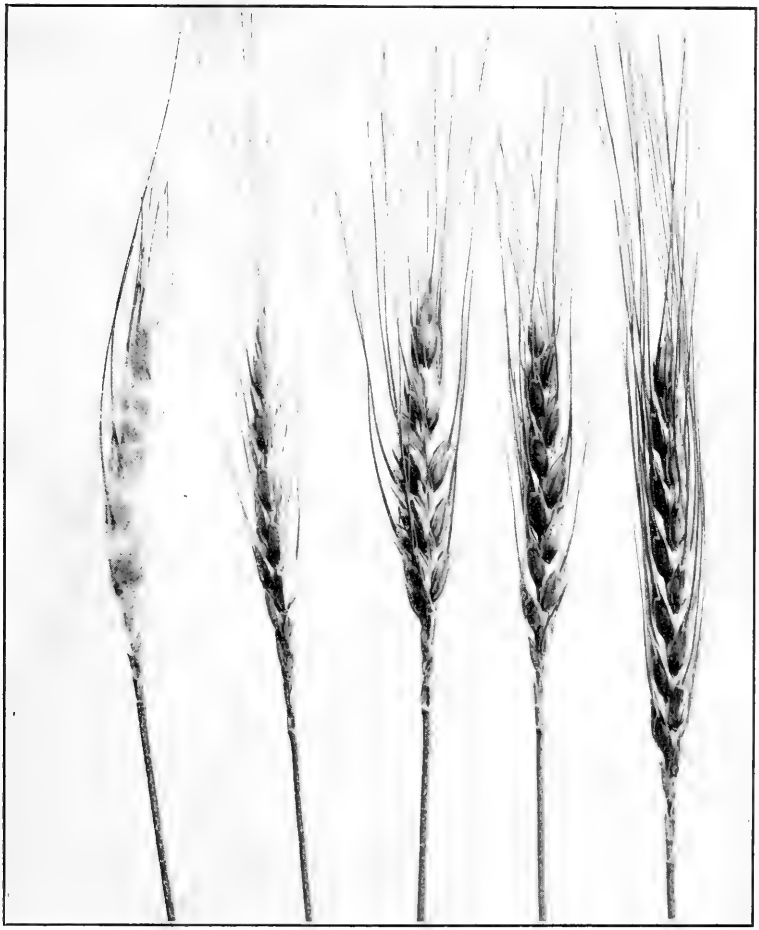


Fig. 38.—Heads of wheat which have been dwarfed and blighted by scab (Fusarium culmorum). The head overgrown with the cottony mycelium was kept in a damp chamber over night. Original.

the branches of a heavily laden fruit tree. With the onset of the first warm rains of spring, the "cedar apples" produce numerous orange-colored projections which stand out in all directions and thus give rise to the characteristic gelatinous rosette-like structures. I have known people to admire the "cedar apples" as the true fruit of the cedar, or to

Fig. 39.—Peach leaves deformed by "leaf-curl" (Exoascus deformans). Original.

look upon the gelatinous rosettes as the flowers of the cedar, little realizing that the structures are not normal, but due to a parasitic fungus which may often seriously affect the life of the cedar and greatly impair the productiveness of adjacent apple orchards. The gelatinous projec-

Fig. 40.—Head smut (Sphacelotheca reiliana) of sorghum. Original.

tions soon dry up and leave the old dead galls hanging upon the branches.

Here may also be mentioned the disease of plums and cherries known as "black-knot." This disease is often not noticed until the conspicuous black enlargements become evident later in the season. The enlarge-

Fig. 41.—Cedar apples (Gymnosporangium juniperi-virginianæ) on the common cedar, one mature and the other from the previous season. Original.

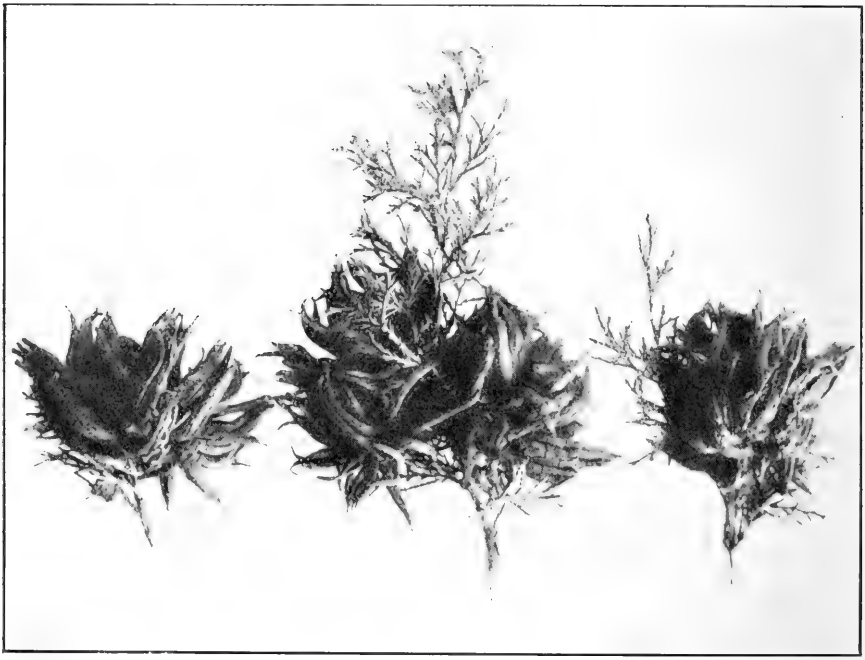


Fig. 42.—Cedar apples showing the production of the gelatinous sori. Spring stage. Original.

ments are somewhat irregular, roughened, and generally extend for some distance along the length of the affected twigs. When young or in the early spring the newly formed knots are olive green in color. In this

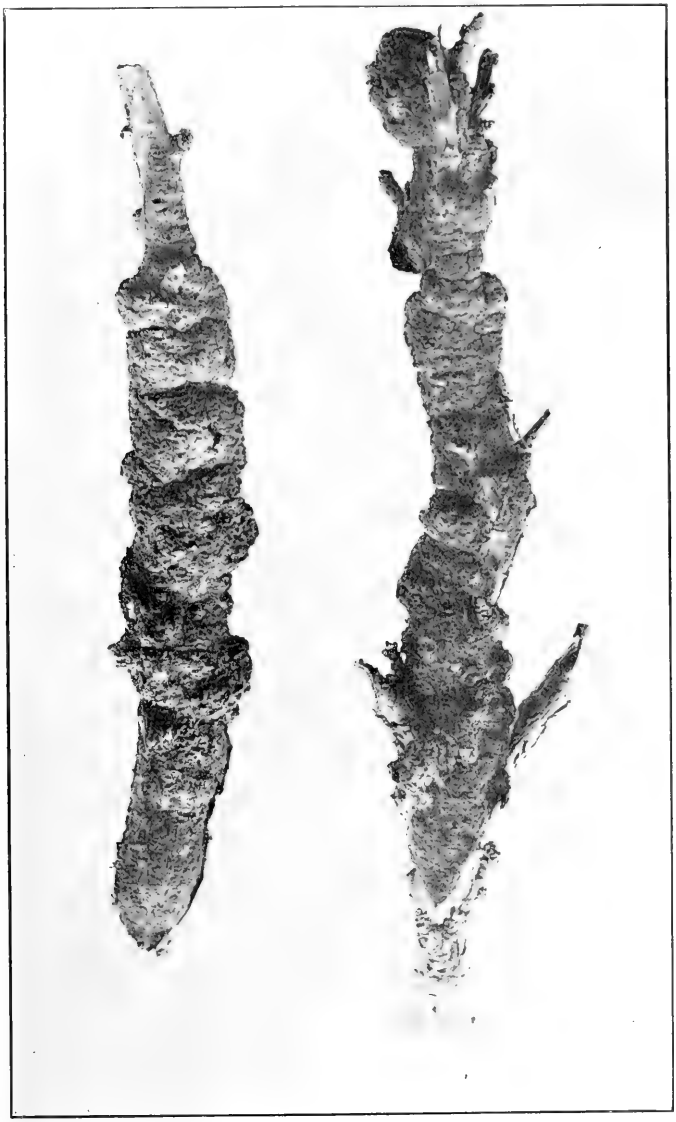


Fig. 43.—Black knot (Plowrightia morbosa) on the Burbank plum. Original.

condition they produce a crop of spores that spreads the disease, while later the older knots produce a second kind of spores. The fungus that causes the black-knot lives perennially in the twigs and branches

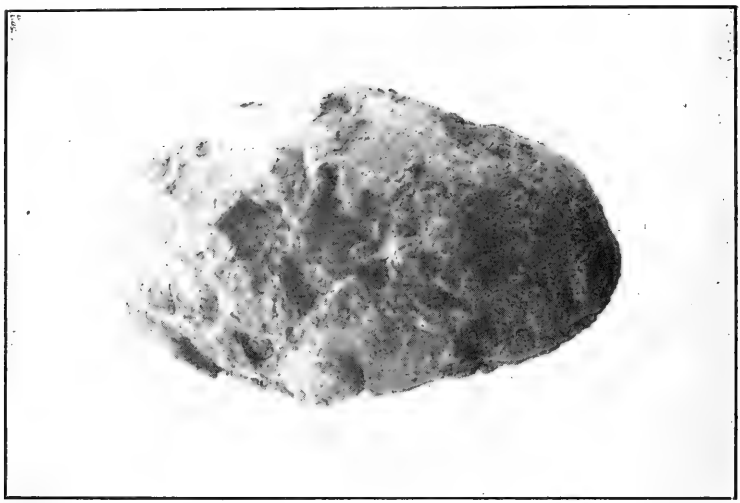


Fig. 44.—Potato showing deep scab and surface spots (Oospora scabies). Original.

and consequently new growths appear each year unless the affected limbs are pruned off. In several sections of the United States plum orchards are seriously affected, and it is not uncommon to find the wild plums in many regions covered with malformations of the character described.

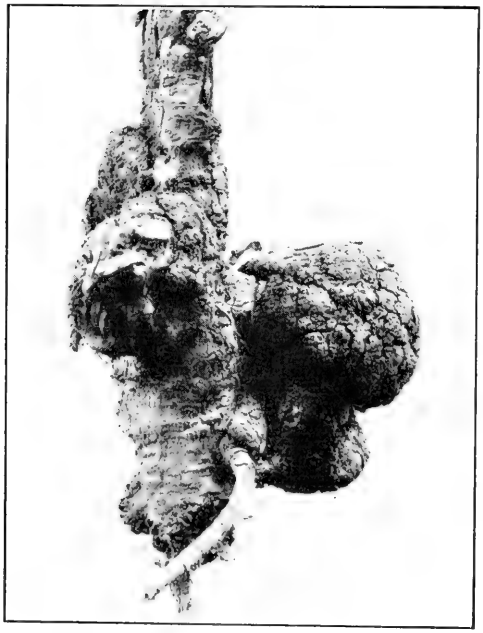


Fig. 45.—Crown-gall on the peach. Original.

In some fungous diseases the malformations do not show as pronounced enlargements. This is true in our common potato scab, in which irregular roughened areas appear over the surface of the potato. An abnormal development of the corky tissue may result in a slight elevation of the scab patch, or in the deep form there may be more or less corrosion and destruction of tissue.

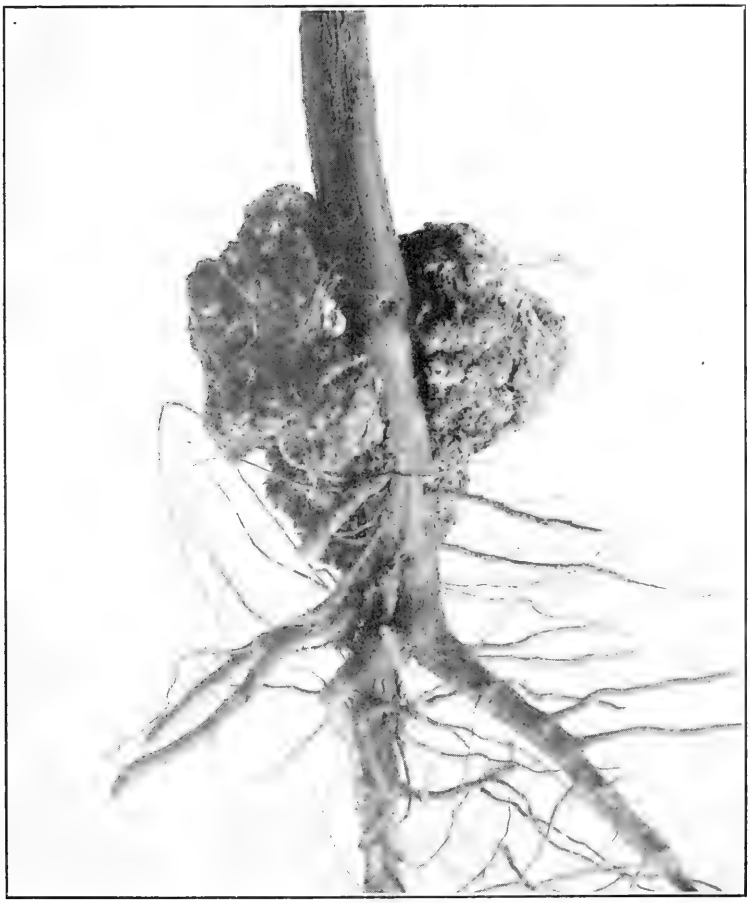


Fig. 46.—Crown-gall on the raspberry. Original.

The so-called crown-galls which may be called our "vegetable cancers" are due to the stimulating effect of some organism in the majority of cases. In these cases irregular abnormal enlargements appear at the crown or even upon some of the roots as in the raspberry, blackberry, grape, peach, apricot, and apple. The general similarity of the abnormal formations produced upon different hosts in these crown-gall diseases is

shown in the accompanying illustrations. The peach tree from which the photograph was taken had been killed as a result of the disease, while the raspberry plants which frequently showed large galls gave little indication that they were seriously affected by the disease. Some of the vegetable cancers are apparently infectious, while others do not appear to be caused by the presence of a parasite and must be caused by a "rebellion of certain body cells" of the plant, just as human cancers are produced by similar deviations from the normal.

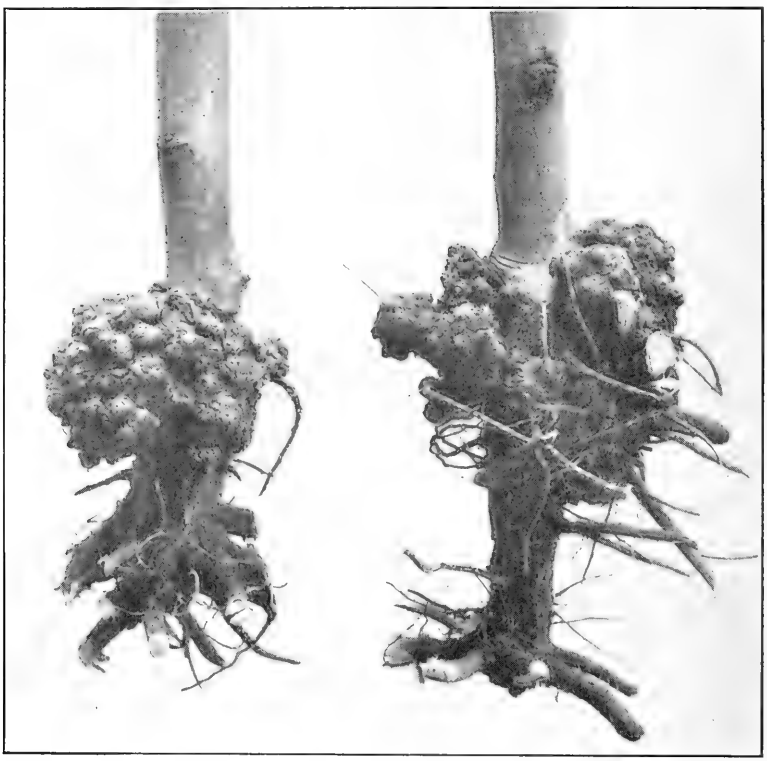


Fig. 47.—Two young apple trees affected with crown-gall. Original.

The club-root or finger-and-toe disease of the cabbage and other cruciferous plants should also be included in this category, while the tubercles produced upon the roots of various leguminous plants, either wild or cultivated, are not injurious, but are decidedly beneficial since the presence of the bacteria in these tubercles makes it possible for the legume to utilize the free nitrogen of the air. These tubercles on the roots of our common garden peas are especially large, and our native Texas Lupine or Blue-bonnet has root-tubercles of pronounced size.

The name "canker" is applied to a malformation in the bark of trees which generally results in an open wound. In the younger stages of a canker the bark may be only slightly different from the normal, sometimes being sunken, sometimes showing a more tumid condition. The canker area may also show differences of color, and with the advance of the disease the bark becomes roughened and begins to break and peel away. The destruction of the cortex or bark may thus leave an open

Fig. 48.—Canker on apple limb. Original.

wound which exposes the wood, while the parasite itself penetrates the wood deeper and deeper, or other wood-rotting fungi gain an entrance and help complete the destruction. There are at least six different canker producing fungi which grow upon apples trees. The same organism which produces the canker may also cause a rotting of the fruit. This is true in the bitter rot canker, the black rot canker, and the Pacific coast canker, while the organisms which cause European canker, the Illinois

apple tree canker, and fire-blight canker do not attack the fruit. In some cases open wounds on trees due to sun-scald may be confused with cankers due to fungi, but in general a careful observation of the location will reveal the difference. Canker-producing fungi may, however, enter sun-scald wounds and continue the destruction. A bacterial canker of

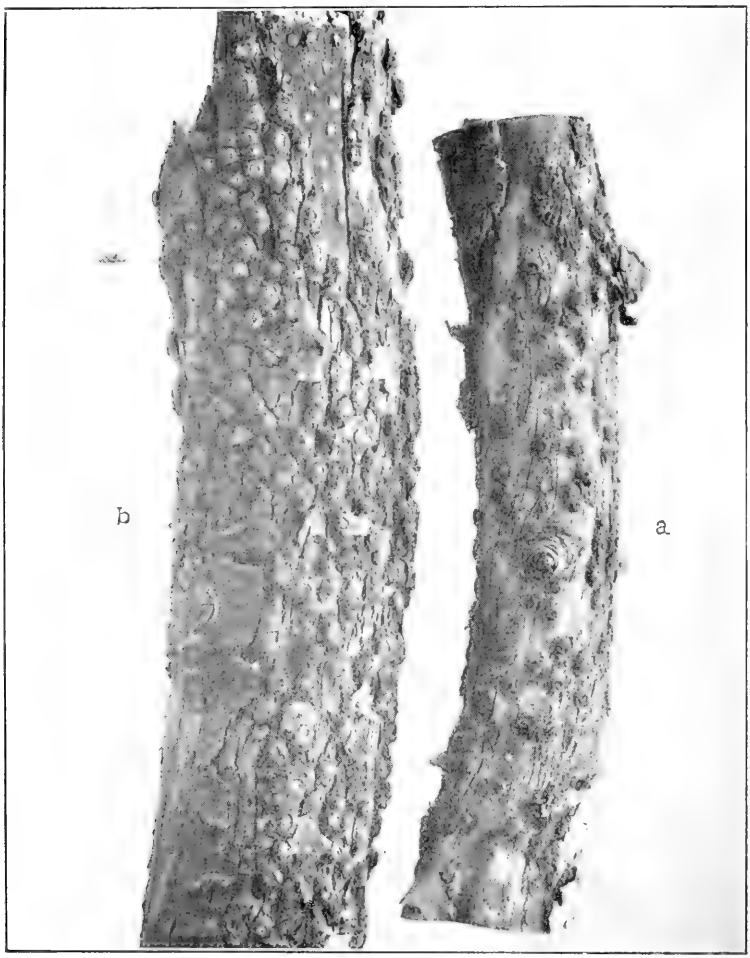


Fig. 49.—Branches of apple limbs affected with Illinois canker (Nummularia discreta). (a) Old canker; (b) mature canker. Photograph by F. A. Wolf and F. D. Heald.

plums has been observed especially upon two varieties, the Wickson and Whitaker. These plum cankers are on the smaller branches and are produced by radial fissures in the bark which make more or less open wounds due to the destruction of tissues and the relief of the transverse tension.

It is not uncommon to find upon the trunk or limbs of forest, ornamental, or orchard trees the fruits or *sporophores* of some of the higher fungi. Some of these common forms are toadstool-like in appearance, while others are in the form of brackets, the so-called bracket fungi. The latter are often called "punks" or "conchs" by lumbermen and foresters. Some of these higher fungi only grow in wood or branches that are dead or in a languid condition, while others may gain an entrance through open wounds into healthy limbs and begin the work of destruction, while still others are more virulent and do not require either of the above conditions. In general, these fruits of fleshy fungi upon a woody plant may be considered indicators of disease, and they should be destroyed as soon

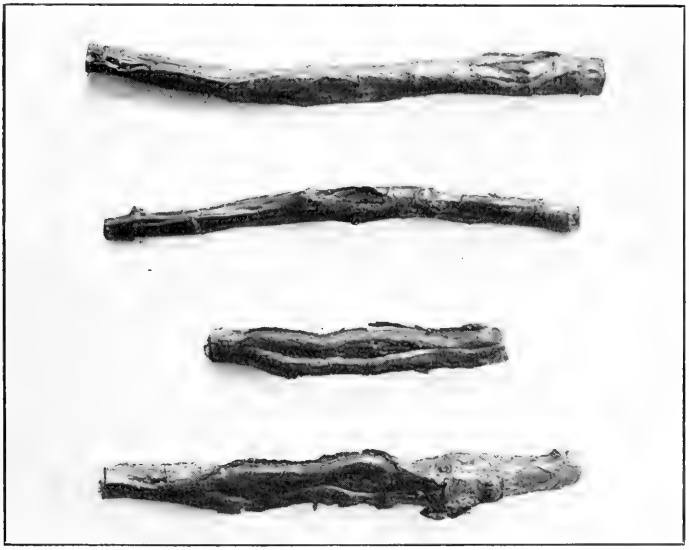


Fig. 50.—Plum twigs showing cankers produced by bacteria. Original.

as they appear to prevent the spread to other trees. The wood of a tree is always well pervaded by the vegetative body of the fungus and partially disintegrated before these sporophores appear, and although the life of the tree is generally doomed it may often be prolonged by proper care. When orchardists recognize the fact that wounds should be protected to prevent infection, there will be less trouble from wood-destroying fungi.

In certain cases the fungus gains an entrance to the tree through improper pruning. If short spurs of the branches are left, the tissue dies back to the main axis and the fungus finds in these dead spurs an easy lodgment. The accompanying illustration of a cherry branch shows such spurs and the *sporophores* of a fungus which entered through them.

The broom-like tufts of branches which appear on the silver fir, cedar, birches, cherry, and other trees are popularly called witches' brooms. In the majority of cases a rust fungus is the cause of the abnormal proliferation, and the resulting branches generally stand more or less erect, giving the characteristic broom-like effect. Insects may in some cases be the cause of witches' brooms, but there are numerous instances in

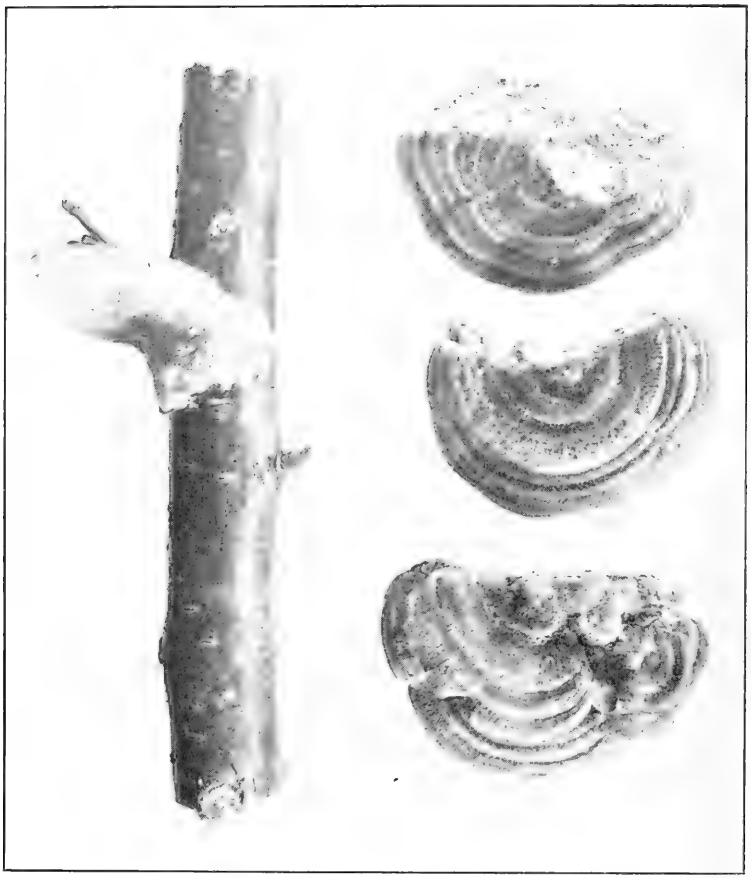


Fig. 51.—Sporophores or fruiting bodies of a wound fungus on the cherry. Original.

which the causal organism has not yet been observed. The witches' broom of our common hackberry is due either to an insect alone or to an insect and fungus working together. Cockscomb-like growths are closely related to witches' brooms in their manner of formation. In growths of this sort on the gooseberry, a louse and a mildew are quite constantly present.

While the formation of rosettes is the normal form of growth in many plants, such as dandelion, shepherd's purse, lettuce, and others, the appearance of rosettes or the assumption of the rosette habit is a sure in-

Fig. 52.—Sporophores of fungus (Schizophyllum commune) on cherry. Shows the short spurs left by improper pruning, which allowed the entrance the fungus. Original.

dication of disease in several cases. Very good examples of this symptom are to be observed in the "rosette disease" of the potato and in the "peach rosette." Both of these diseases are at present confined to the eastern and southern part of the United States.

The root system of a plant may also show an abnormal abundance of branches giving rise to a tufted mass of fine fibrous roots. This condi-

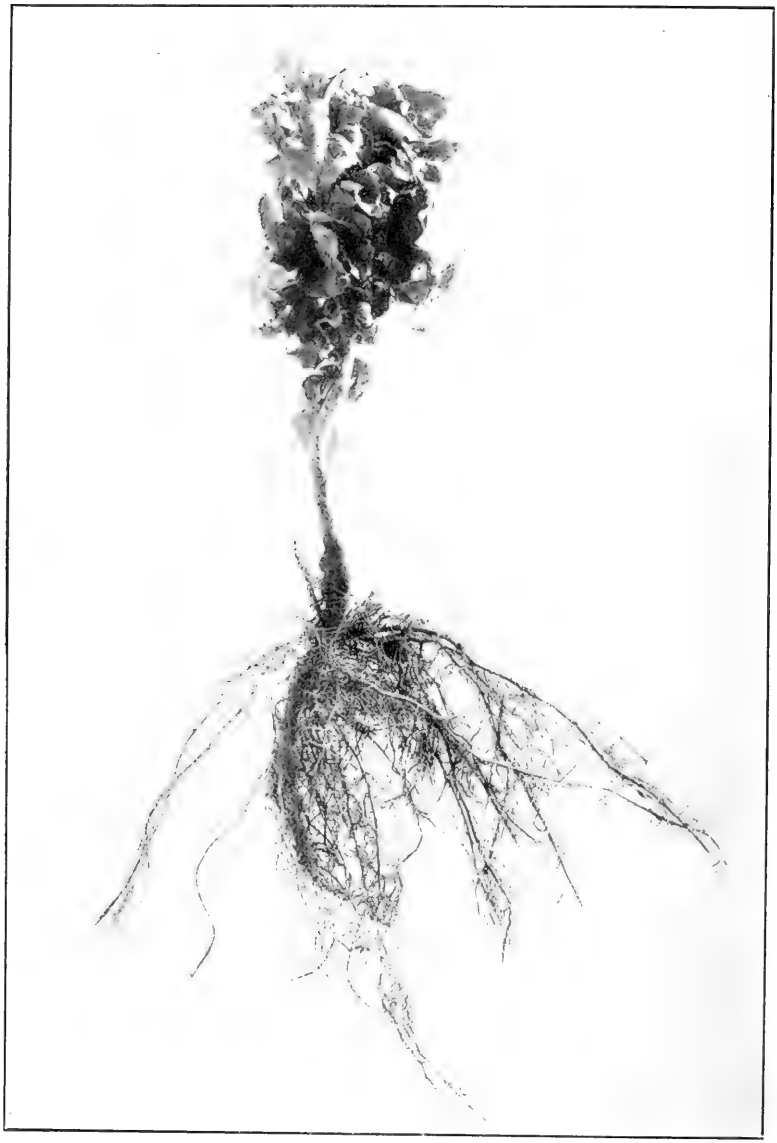


Fig. 53.—Cherry tree showing "hairy root." The shoot also shows a marked rosette arrangement of the leaves. Original.

tion is designated as the "hairy root," and it may be accompanied by an abnormal aggregation of the leaves and branches in the shoot. This is well shown in the accompanying illustration of a young cherry tree.

There are many diseases in which the outflow of a slimy, gummy, or resinous substance is a characteristic symptom. In the so-called "slime-flux" of deciduous trees the exudation is semi-fluid in nature and does not set into a solid substance with the accumulation of the excretion. This symptom may indicate a parasitic organism or it may be due to deep-

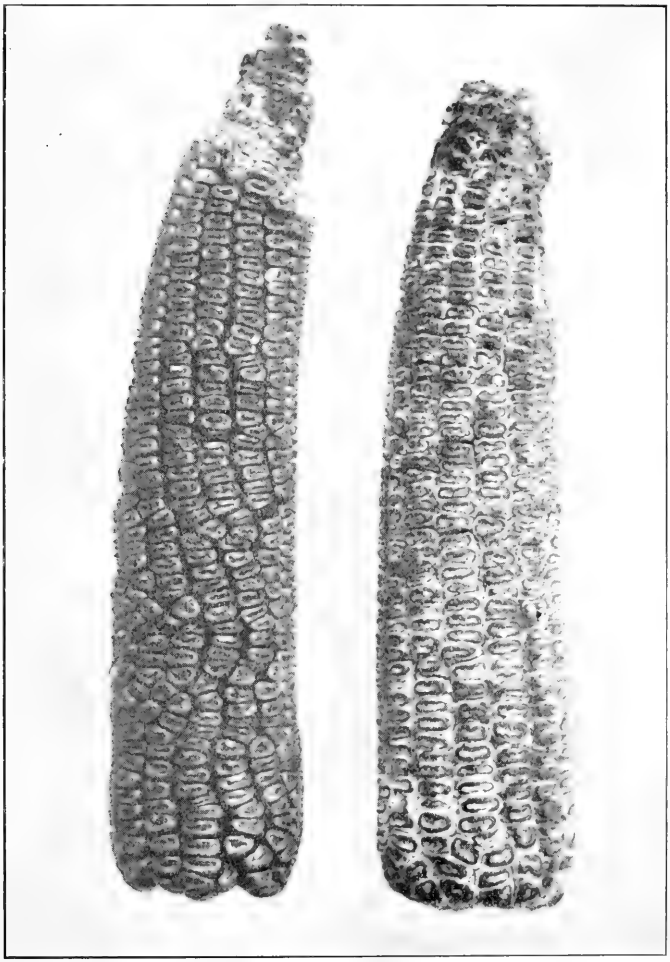


Fig. 54.—Normal ear of corn and one affected with dry-rot (Diplodia zeae). Original.

seated physiological disturbances induced by other factors. In coniferous trees in which an excretion of resin is a normal phenomenon, we often find an abnormal increase as a result of disease. One of the first symptoms attending the presence of wood-destroying fungi in our forest evergreens is this abnormal production of pitch or resin. This symptom is

frequently noticeable before the *sporophores* of the fungus make their appearance on the surface of the trunk. The production of a clear or amber-colored secretion which accumulates upon the surface of trunk, branches or even small twigs is characteristic of the *"gummosis"* of cherries and other stone fruits. This material generally sets into more or less solid nodular or flattened masses, and the fruit itself often shows numerous *"gummiperlen."* In peaches and plums the fruit from affected trees often shows a splitting apart of the halves of the pit or stone. In general, however, cherry trees and peach trees suffer more from *gummosis* than any other stone fruits. In some cases *gummosis* is induced by wounds; in others it is a symptom attending the presence of a fungus

Fig. 55.—Cross section of the fruit of an egg-plant rotted by a fungus (Phyllosticta hortorum). Original.

parasite; while in many instances it is due to a deep-seated disturbance of the nutritive processes which results in the decomposition of more or less extensive masses of tissue. Some of the external factors which especially favor or predispose to this trouble are heavy soils, high levels of ground water, deep planting, and transplanting at inopportune times.

The rotting of parts or organs of a plant, the "gangrene" of plant tissue is always due to the presence of some organism, either a fungus or bacterium. In some cases there may be a slow decomposition of the tissue without any liquefaction or softening of the affected parts. In these "dry rots" the parasitic organism gradually digests cell-wall or reserve food materials, or both, with the result that living cells are deprived

of their necessary food, and succumb or are directly attacked, while mechanical tissues are weakened and fail to perform their normal functions.

Fig. 56.—A root-rot of cotton. Plants show a marked constriction of the stem and numerous wart-like pustules. Photograph by F. D. Heald and F. A. Wolf.

In other cases the rotting may be fairly rapid, with more or less liquefaction and softening and discoloration of the affected parts. In these

"soft-rots" the fungus or bacterium generally spreads rapidly through the affected parts in case favorable conditions prevail.

There are no parts of a plant that are exempt from rotting, but in general the dormant or languid parts are more likely to suffer from the inroads of rot-producing organisms. Nearly all the troubles in which rotting is a characteristic symptom may be grouped under the head of root-rots, stem or trunk rots, bud rots, and fruit rots.

Plants with fleshy or woody roots often have their root system invaded by parasitic or semi-parasitic organisms, which work in such a way as to give rise to disease generally characterized as root-rot. Woody roots generally undergo such changes that the trouble is characterized as a dry

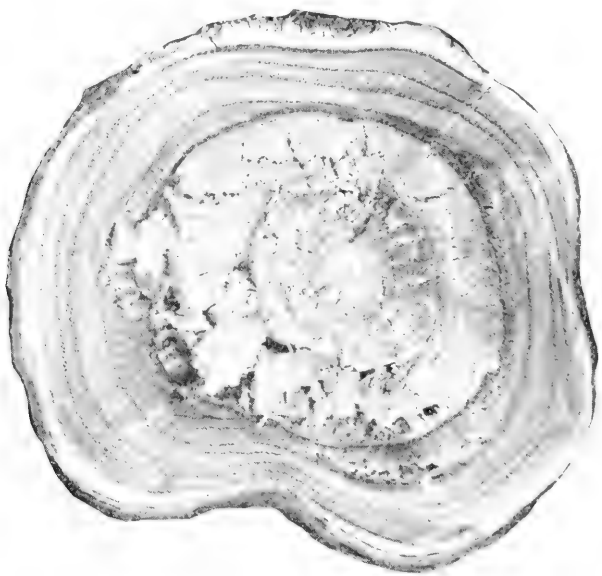


Fig. 57.—Cross section of the trunk of a catalpa tree. Central portion has been disintegrated by the action of a fungus (Polyporus versicolor). Original.

rot, while fleshy roots that are gorged with reserve food material often of a saccharine nature are more likely to be affected by organisms causing a soft rot. Our root crops, such as beets, turnips, carrots, and sweet potatoes, are often affected. Sometimes the organism that causes the rotting gains an entrance while the roots are still growing in the field or garden, and continues the work of destruction after the crop is harvested and in storage. At other times the rot-producing organisms only gain an entrance after the crop is harvested and in storage or while the roots are in a dormant or languid condition and so less able to withstand the attack. The soft rots of beets, turnips, and carrots are frequently due to bacteria, while the soft rots of sweet potatoes are of fungus origin. Much

can be done to prevent these troubles by proper measures in the field and storage under conditions that are unfavorable for the growth of either bacteria or fungi.

Alfalfa, clover, and cotton often suffer from root-rots to such an extent as to cause serious loss. In one such disease of alfalfa the affected field will show small circular patches of dead plants which increase in circumference as the fungus advances through the soil. In another case the dying and dead plants are scattered throughout the field and show a rotting of the root of a different character. The evidence at hand leads to

Fig. 58.—Portion of a slab of cottonwood, showing the effect of a wood-destroying fungus (Elfvingia megaloma). Original.

the opinion that this last type of root-rot is induced primarily by either unfavorable soil or climatic factors, or both, which so lowers the tone and vigor of the plants that various saprophytic forms come in and complete the work of destruction. Two different root-rots of cotton are known. One of these is very common in Texas and has received the common name of the "Texas root-rot." It is not uncommon to find fields in which 25 to 75 per cent of the crop has been ruined by the inroads of these root-rotting parasites.

Some of our fruit trees, such as the cherry and apple, and also forest

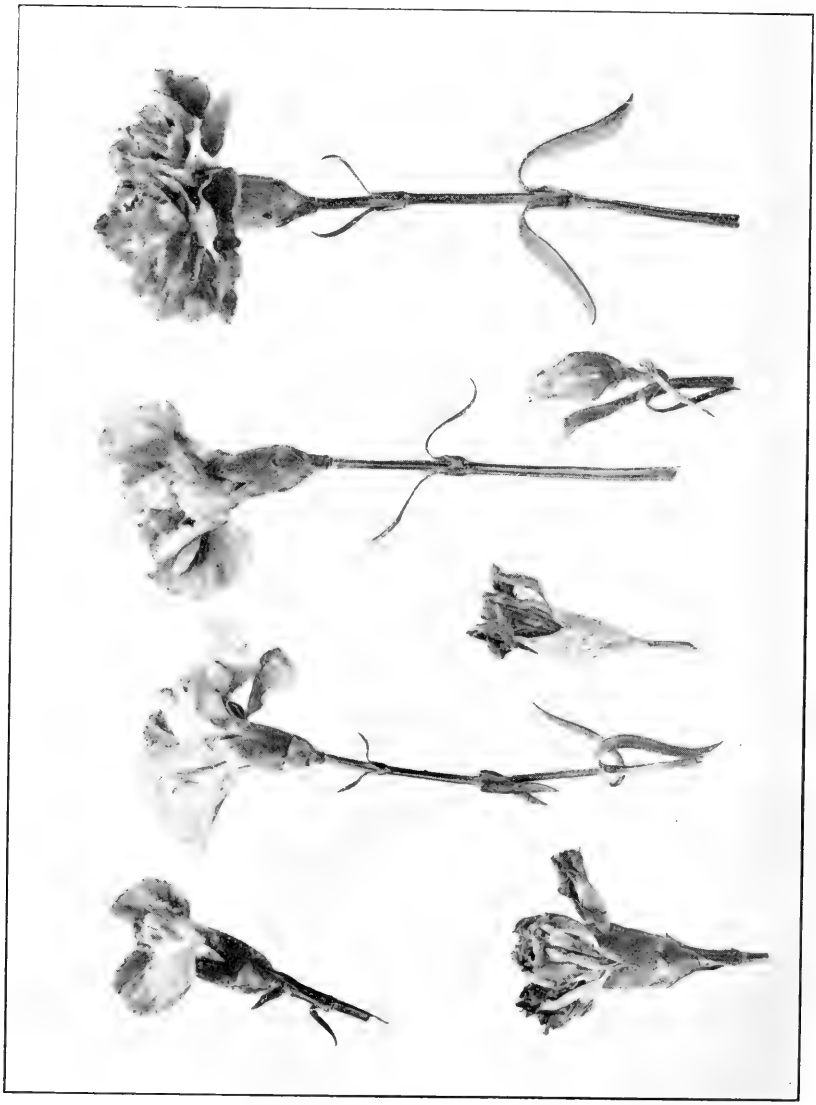


Fig. 59.—Normal "Lawson" carnation and series showing the effect of bud-rot fungus (Sporotrichum poae). Original.

and shade trees, are attacked by root-rotting fungi. The wood of root and even the crown is slowly disintegrated, and the mechanical structures are so weakened that severe storms may cause the affected tree to be blown over. White strands or fibrils, the vegetative body of the fungus, may sometimes be seen upon the fractured surface. In other cases the affected tree may remain standing until it finally succumbs to the attack.

Modified stems, like tubers, rhizomes, bulbs, or corms, which serve as storage organs for reserve food, suffer in many cases from rot-producing fungi or bacteria. These storage organs are affected in much the same

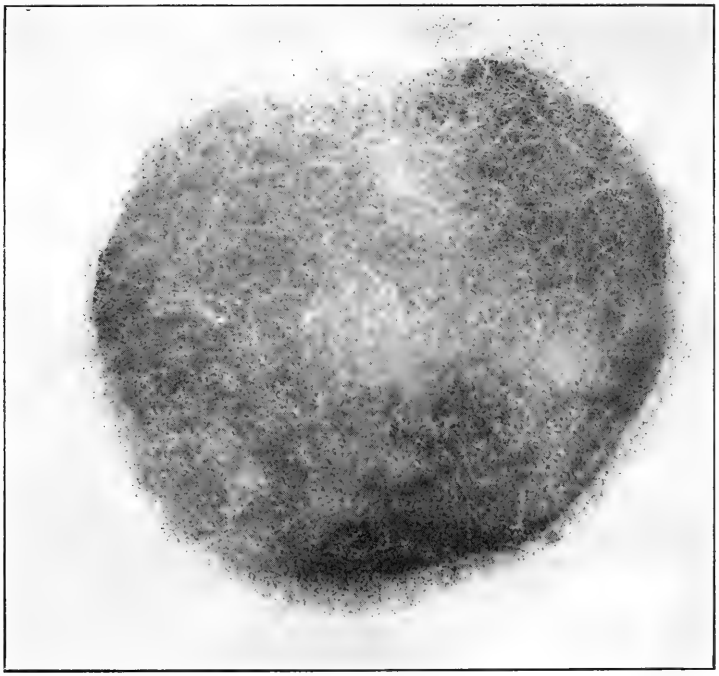


Fig. 60.—Apple rotted by black mold (Rhizopus nigricans). Specimen was placed in a damp chamber to cause the mold to grow over the surface. Original.

way as the fleshy roots, but dry rots are not uncommon. The potato is affected by several diseases in which a soft rot of the tubers is a marked symptom. This is true in the disease known as the late blight, a fungus disease, and also in the bacterial blights, while in some cases a soft rot may result when the tops are not affected. In the dry-rot of the potato the fibro-vascular ring often shows a conspicuous darkening when the tubers are cut across, and the badly rotted portions become shrunken and darkened and more or less corroded. Diseases of this kind may be spread by planting affected seed. Iris rhizomes, canna root-stocks,

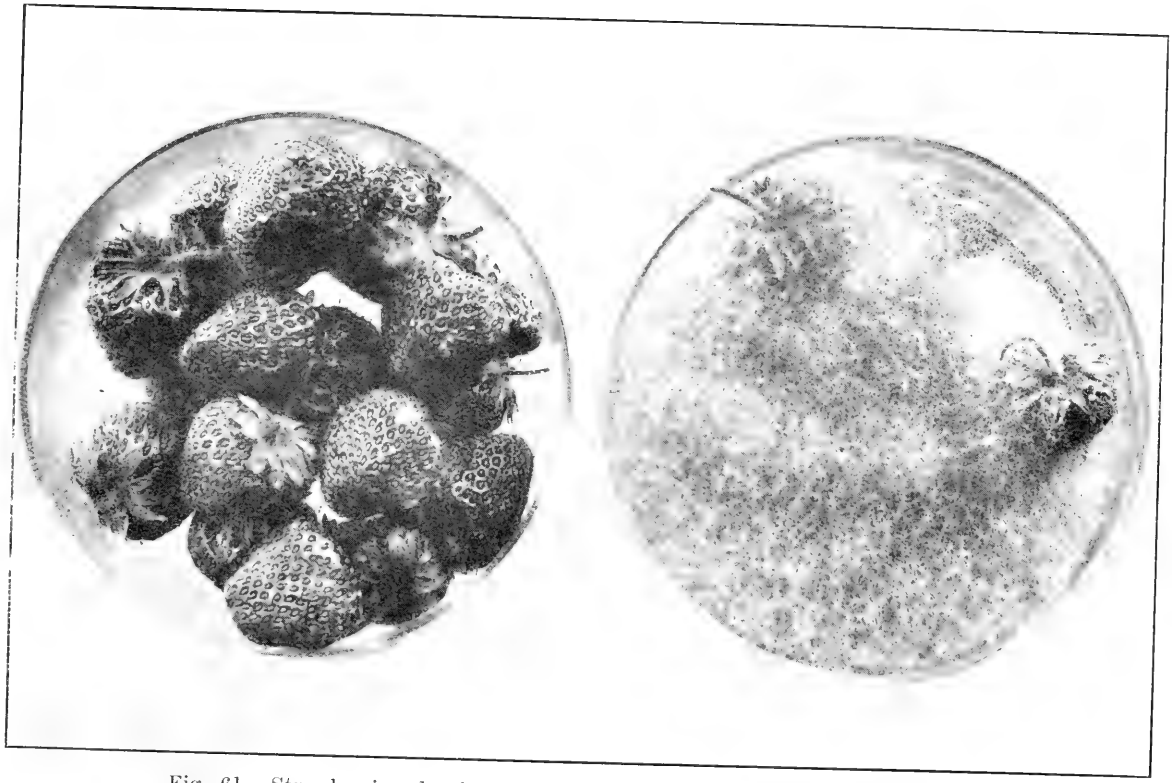


Fig. 61.—Strawberries showing the effect of formalin treatment in preventing the growth of black mold (Rhizopus nigricans). Photograph by F. D. Heald and Leva Walker.

hyacinth or calla lily bulbs, onions and similar modified storage organs are often affected by organisms which produce soft rots.

An immense amount of loss is caused in standing timber and in fruit trees from dry-rots of the trunk due to wood-destroying fungi which gain an entrance through wounds or otherwise. It frequently happens that the trunk of a tree is thoroughly permeated by the vegetative *hyphae* of the fungus before any external evidences of its presence can be detected. These wood-destroying fungi may give rise to external fruiting bodies, either toadstool-like or bracket *sporophores,* when they have reached a sufficient vigor of growth. The affected wood is gradually disintegrated by the work of the fungus which digests the woody elements. It is thus transformed into a brittle or even punky condition that renders it unfit for the purposes which it must serve as a functional part of the tree, and lessens or destroys the value of the wood for lumber. Wood affected by dry-rot is often discolored, sometimes showing a marked blue, pink, yellow, or reddish-brown coloration. Black lines may often be noticed crossing irregularly through the wood or surrounding definite areas. The vegetative body of the fungus is frequently invisible to the naked eye, but in some cases it shows as fine strands or ropes, or even lamellae that run between the wood fibers or along the silver grain.

In a few cases buds are affected by rot-producing fungi or bacteria. In the tropical regions the cocoanut is seriously affected by a bacterium which causes a rotting of the large terminal bud. In this connection the black rot of the cabbage may be mentioned, for the cabbage is really a large bud. This disease is of bacterial origin, the organism entering at the leaf margins. They make their way down through the veins to the central axis and frequently cause a complete rotting of the fully or partially developed heads. This disease is particularly destructive on low, heavy soils. One of the best illustrations of a fungus bud-rot is to be observed in a serious disease of certain varieties of greenhouse carnations. In this disease the fungus may gain an entrance into the bud at an early stage of its development, and cause a complete rotting of the petals before the calyx has opened. In other cases the rotting starts later and the flower may be partially opened before its development is arrested. In these affected flowers the claws of the petals will be brown and soft even though the exposed portions are normal in appearance. A minute mite is constantly associated with this disease and the evidence points to the fact that the mite acts as a carrier for the fungus, transferring it from bud to bud.

The rotting of fruit is always caused by the inroads of bacteria or fungi. In the majority of cases it is some filamentous fungus that causes the trouble. The fruit-rotting fungi may gain an entrance through wounds or bruises, or in other cases they may penetrate the uninjured

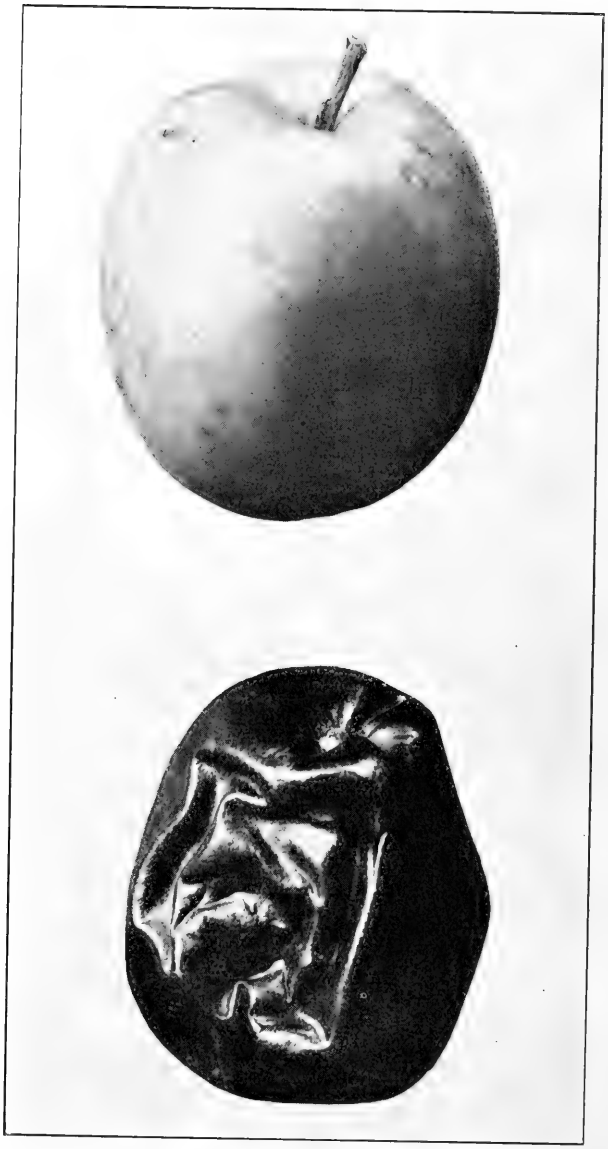
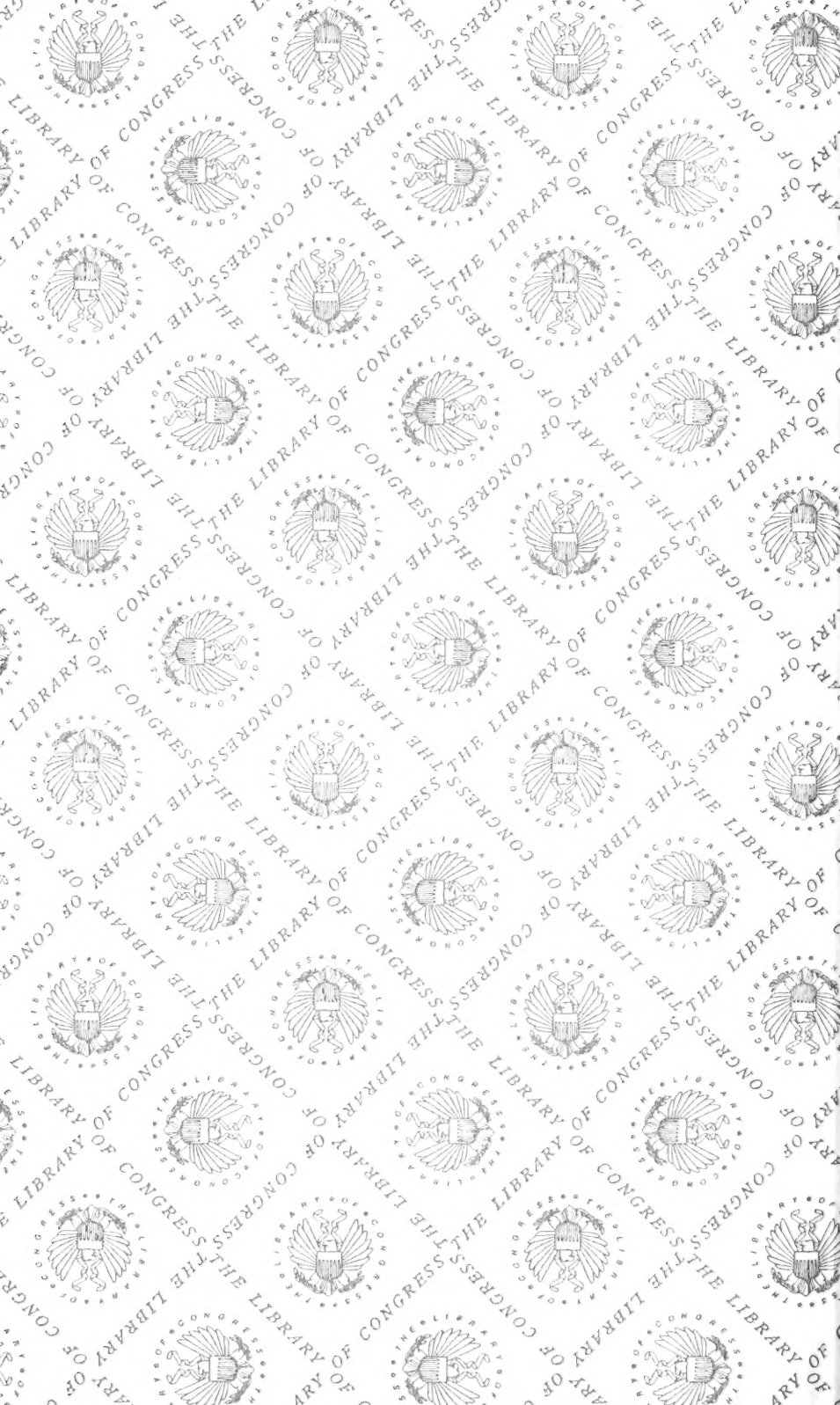


Fig. 62.—Normal Bellflower apple and coal black "mummy" produced by brown rot fungus (Sclerotinia fructigena). Original.

skin. In some cases the rotting may begin when the fruit is still immature and hanging on the tree, and the work of destruction may be continued after the crop is harvested. Many fruit-rotting fungi only attack the ripe fruit, just at time of maturity or after it has been harvested or during storage. Soft fruits, like strawberries, suffer rapid decay from fungi, while fruits like apples with a protective epidermis may be preserved for a long time.

The brown rot of peaches, plums and cherries is very destructive in certain regions when conditions become favorable. Affected fruits show brown patches of soft tissue. The patches spread rapidly in circumference until the whole fruit is involved, and if the weather is moist these rotted areas will show conspicuous pale brown conidial tufts which produce myriads of spores that spread the rot to other fruits. It is these rotting fruits that produce the "mummies" already mentioned. A fungus similar to that which causes the brown rot of peaches, plums, and cherries also affects the apple. It may work in the same way, or it may transform the apple into a black mummy, shiny and coal black, with no external evidence of the fungus. This rot of the apple should not be confused with the true black rot which works in a somewhat similar way. In the true black rot the surface of the apple soon becomes covered with minute black pustules and the fruit becomes more or less shriveled and shrunken. In both the black rot and the brown rot the pulp is colored a dark brown, the black coloration being due to changes in the skin. The bitter rot shows brown circular areas with concentric zones of pink spore-pustules. This is one of the most destructive apple diseases known for the central Mississippi Valley region, especially for southern Illinois and Missouri and adjacent territory. Green mold is one of the most destructive fungi for stored apples. Apples affected by this rot often show only brown patches in which the tissue becomes rapidly softened and the whole apple transformed into a soft rotten mass. In moist conditions the bluish-green spore-tufts of the fungus may be seen upon the surface of the fruit. In addition to the various rots mentioned, a white rot of the apple has been recently observed in which the entire pulp may be transformed into a soft mass without any discoloration. By paying attention to proper spraying to prevent insect injuries and other fungus diseases, by careful handling in harvesting, and by storage under conditions that retard the growth of fungi, much of the trouble from rotting of apples can be prevented.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