Chapter 3 Plant Diseases and Their Pathogens

Because this is a reference book and not one to be read for pleasure or continuity, most of you will come to the material you need in this section by way of the index or the lists of diseases given under the different hosts in ► Chap. 4. At the beginning of ► Chap. 4 you will find a list of headings under which diseases are grouped and described, from Anthracnose to Witchweed. In the Host section, ► Chap. 4, the key word, for example, rot or blight, is given in capital and small capitals, followed by the name of the pathogen (agent causing disease) in boldface. In this Diseases section, Chap. 3, the pathogens are listed in boldface in alphabetical order under each heading such as ROTS or BLIGHTS and so on, followed by the common name of the disease. This system was adopted for quick and easy reference because trying to alphabetize hundreds of similar common names would lead to endless confusion. Also, it allows a very brief summary of the classification and diagnostic characters of each genus before going on to a consideration of diseases caused by the various species. This brief summary is in small type, so that it can be readily skipped by readers uninterested in the technical details. Perhaps I am the only one who feels the need for this quick review, to be used in conjunction with the classification given in ► Chap. 2; perhaps others who have to answer questions over a broad field instead of their own specialty can make use of these capsules sandwiched in between nontechnical descriptions.

An alphabetical arrangement has the great disadvantage of being thrown out of alignment every time the name of a fungus is changed, as it so frequently is. In some such cases the old name is retained to avoid change in order, but the present accepted name is also given. Sometimes names have been changed under several hosts and the old name inadvertently retained under others. And sometimes the old name is purposely retained because it is so familiar to everyone. This is particularly true of a few fungi far better known by their anamorph states than by the correct name of the teleomorph state.

A fungus not only can have several names; it also can cause more than one type of disease. For instance, *Pellicularia filamentosa* is the present name of the fungus formerly known as *Corticium vagum* when causing Rhizoctonia rot of potatoes and *Corticium microsclerotia* when causing web blight of beans. As *Rhizoctonia solani*, the name given to the sclerotial stage, the same fungus causes damping-off of seedlings, root rots of many plants, and brown patch of lawn grasses. There are lots of plant diseases, and there are lots of fungi causing them, but there are not nearly as many separate pathogenic organisms as all the names would indicate. Thus, a Linkage Reference guides the user to two or more common disease sites, i. e. "Canker" or "Blight", where the user searches for the pathogen alphabetically or the link may guide the user directly to a pathogen in another chapter or section.

I cannot think of anything more deadly than ploughing straight through this section from Anthracnose to Wilts. By doctor's orders, take it in small doses, as needed. But do read the few introductory remarks as you look up each group, and please, please, before starting any control measures, read the opening remarks in ▸Chap. 1 on Garden Chemicals, and look up, in the list of chemicals, any material you propose to use, noting precautions to be taken along the lines of compatibility, weather relations, and phytotoxicity.

Although the disease descriptions, fungus life cycles, and general principles of control given here will remain fairly valid, it must be stressed that chemicals suggested for control are constantly changing. Today's discovery may be obsolete tomorrow. This *Plant Disease Handbook* should, therefore, be used in conjunction with the latest advice from your own county agent or experiment station. Addresses of the state agricultural experiment stations are given following ▸Chap. 4.

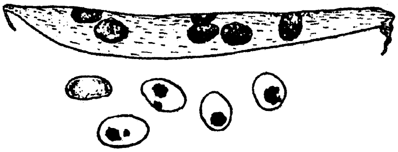
ANTHRACNOSE

The term “anthracnose” has been used for two distinct types of disease, one characterized by a typical necrotic spot, a lesion of dead tissue, and the other by some hyperplastic symptom, such as a raised border around a more or less depressed center. The word was coined in France for the latter type, to differentiate a grape disease from a smut of cereals, both of which were called *charbon*. The new word was taken from the Greek *Anthrax* (carbuncle) and *nosos* (disease), and was first used for the grape disease, caused by *Sphaceloma ampelina*, the chief symptom of which was a bird’s-eye spot with a raised border.

A disease of brambles, raspberry and blackberry, was then named anthracnose because it looked like the grape disease. The fungus, however, instead of being correctly placed in the genus *Sphaceloma*, was mistakenly named *Gloeosporium venetum*. The next disease entering the picture was a bean trouble, and, because the fungus was identified as *Gloeosporium* (though later transferred to the genus *Colletotrichum*), this common bean disease with typical necrotic symptoms was also called anthracnose and came to typify diseases so designated.

The term “spot anthracnose” has been given to those diseases similar to the original hyperplastic grape disease. Those with slight hyperplastic symptoms are still commonly called anthracnose, and those with pronounced overgrowth of tissue are commonly called scab. Both types are caused by the genus *Elsinoë*, anamorph state *Sphaceloma*, and are treated, in this revised text, as a separate group. ► Spot Anthracnose.

Anthracnose in the modern sense is a disease characterized by distinctive limited lesions on stem, leaf, or fruit, often accompanied by dieback and usually caused by a *Gloeosporium* or a *Colletotrichum*, anamorph fungi producing slime spores oozing out of fruiting bodies (acervuli) in wet, pinkish pustules. These spores (conidia) on germinating form an appressorium (organ of attachment) before entering the host plant. The teleomorph state of the fungus, when known, is *Gnomonia* or *Glomerella* (see Fig. 3.1).



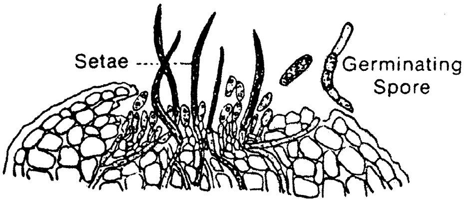


Figure 3.1 Bean Anthracnose. Pod and seeds with dark, sunken areas; section through bean seed showing spores formed in an acervulus marked with prominent black setae

Apiognomonia

Apiognomonia errabunda (Anamorph, *Gloeosporium quercinum*). **Oak Anthracnose**. See *Discula umbrinella* and Fig. 3.2.

Apiognomonia errabunda (formerly *Gnomonia quercina*). **Oak Anthracnose**. The fungus is closely related to *Gnomonia platani*, usually reported as *G. veneta*, but is now considered a separate species. The anthracnose appears as brown areas adjacent to midribs and lateral veins.

Apiognomonia tiliae (formerly *Gnomonia tiliae*). **Linden Anthracnose**, **Leaf Spot**, **Leaf Blotch**, **Scorch** on American and European linden. Small, circular to irregular brown spots with dark margins form blotches along main veins in leaves, leaf stalks, and young twigs, with rose-colored pustules. In wet seasons, defoliation in early summer may be followed by wilting and death of branches. Cut out and burn such branches.

Apiognomonia veneta (formerly *Gnomonia platani*) (*G. veneta*). **Sycamore Anthracnose**, **Twig Blight**, general on American and Oriental planes (London plane is rather resistant) and on California and Arizona sycamores. The fungus winters as mycelium in fallen leaves, producing perithecia that discharge ascospores when young foliage is breaking out. Mycelium also winters in twig cankers. Young sycamore leaves turn brown and die, looking as if hit by late frost. Leaves infected later in the season have irregular brown areas along the veins. Conidia ooze out from acervuli on underside of veins in flesh-colored masses, in rainy weather, and are splashed to other leaves. Twigs and branches have sunken cankers with more acervuli. Native sycamores may be nearly defoliated, with smaller twigs killed. Larger branches die with several successive wet springs. The trees usually put out a second crop of leaves after defoliation, but this is a devitalizing process. Dead twigs and branches give a witches' broom effect to the trees.

Figure 3.2 Oak Anthracnose

On white oaks anthracnose appears as brown areas adjacent to midribs and lateral veins.
Control. Although raking up and burning all fallen leaves has been stressed for years, the overwintering of the fungus on twigs makes this measure rather ineffective. The spray schedule has called for three applications of bordeaux mixture; a dormant spray, one when the buds swell, and another 7 days later. Trees should be fertilized to stimulate vigorous growth.

Colletotrichum

Deuteromycetes, Coleomycetes

Spores are formed in acervuIi, erumpent, cushionlike masses of hyphae bearing conidiophores and one-celled, hyaline, oblong to fusoid conidia. Acervuli have stiff marginal bristles (setae), which are sometimes hard to see. Conidia (slime-spores), held together by a gelantinous coating, appear pinkish in mass. They are not wind-borne but can be disseminated by wind-splashed rain. On landing on a suitable host, the conidium sends out a short germ tube, which, on contact with the epidermis, enlarges at the tip into a brown thick-walled appressorium. From this, a peglike infection hypha penetrates the cuticle.

Colletotrichum acutatum. **Anthracnose** on almond, strawberry and black gum.
Colletotrichum antirrhini. (► *Glomerella cingulata*). **Snapdragon Anthracnose**, on snapdragon, chiefly in greenhouses, sometimes outdoors in late summer.
Colletotrichum atramentarium (or *C. coccodes*). **Potato Anthracnose**, **Black Dot Disease** on potato stems and stolons following wilt and other stem diseases, occasionally on tomato, eggplant, and pepper; general distribution but minor importance. Starting below the soil surface, brown dead areas extend up and down the stem. The partial girdling causes vines to lose their fresh color and lower leaves to fall. Infection may extend to stolons and roots. The black dots embedded in epidermal cells, inside hollow stems and on tubers, are sclerotia to carry the fungus over winter and to produce conidia the following spring.
The fungus is a wound parasite ordinarily not serious enough to call for control measures other than cleaning up old refuse and using healthy seed potatoes.

Colletotrichum bletiae (► *Glomerella cingulata*) and other species. **Orchid Anthracnose**, **Leaf Spot** on orchids coming in from the tropics.

Colletotrichum capsici. **Ripe Fruit Rot** of pepper.

Colletotrichum coccodes. **Anthracnose** on soybean.

Colletotrichum dematium (formerly *Colletotrichum omnivorum*). **Anthracnose** on aspidistra and hosta. Large, whitish spots with brown margins are formed on leaves and stalks. Remove and burn infected plant parts.

Colletotrichum dematium. **Anthracnose** on spinach.

Colletotrichum dematium f. sp. **spinaciae**. **Spinach Anthracnose**. Known on spinach since 1880 but unimportant in most years. Leaves have few to many circular spots, water-soaked, turning gray or brown, with setae prominent in spore pustules. The fungus is seed-borne.

Colletotrichum dematium f. sp. **truncata**. **Anthracnose** on tomato. Found in Georgia on *Dolichos*.

Colletotrichum erumpens (► *Glomerella cingulata*). **Rhubarb Anthracnose**, **Stalk Rot**.

Colletotrichum fragariae (► *Glomerella cingulata*). **Strawberry Anthracnose** found in Florida and Louisiana.

Colletotrichum fuscum. **Foxglove Anthracnose** small spots to 1/8 inch, circular to angular, brown to purple brown, on leaves; sunken, fusiform lesions on petioles and veins; minute black acervuli, with bristles, in center of spots. Seedlings damp-off, older plants are killed or stunted in warm moist weather. Use clean seed or treat with hot water (131°F for 15 minutes).

Colletotrichum gloeosporioides (► *Glomerella cingulata*). **Lime Anthracnose**, **Withertip**, only on lime in southern Florida.

Colletotrichum graminicola (formerly *Colletotrichum sublineola*). **Anthracnose** on wild rice (*Zizania*).

Colletotrichum graminicola. **Cereal Anthracnose** widely distributed on barley, oats, rye, wheat, sorghum, wild rice (*Zizamia*) and also on cultivated lawn grasses, causing a root decay and stem rot. Leaf spots are small, circular to elliptical, reddish purple, enlarging and fading with age; centers have black acervuli. The fungus winters on seed and plant refuse in or on soil. Improved soil fertility reduces damage from this disease. This pathogen also causes fruit anthracnose of tomato.

Colletotrichum higginsianum. **Turnip Anthracnose**, also on rutabaga, mustard greens, radish, and Chinese cabbage in southeastern states. Very small, circular gray spots on leaves, and elongate brown or gray spots on midrib, petiole, and stem, show pink pustules in centers of dead tissue. Heavily infected leaves turn yellow and die; young seeds in diseased pods may be killed. Mustard variety Southern Curled Giant is highly resistant.

Colletotrichum lagenarium (see *Colletotrichum orbiculare*). **Melon Anthracnose** on muskmelon, watermelon, cucumber, and other cucurbits.

Colletotrichum liliacearum (see *Colletotrichum lilii*). Found on dead stems of daylilies and many other plants and perhaps weakly parasitic.

Colletotrichum lilii (formerly *Colletotrichum liliacearum*). Found on dead stems of daylilies and many other plants and perhaps weakly parasitic.

Colletotrichum lindemuthianum (► *Glomerella lindemuthianum*). **Bean Anthracnose**, a major bean disease, sometimes mistakenly called "rust," generally present in eastern and central states, rare from the Rocky Mountains to the Pacific Coast.

Colletotrichum malvarum. **Hollyhock Anthracnose**, **Seedling Blight** on hollyhock, mallow, and abutilon, particularly destructive to greenhouse seedlings. Black blotches are formed on veins, leaf blades, petioles, and stems. Remove and burn all old plant parts in autumn.

Colletotrichum omnivorum (see *Colletotrichum dematium*). **Anthracnose** on aspidistra and hosta. Large, whitish spots with brown margins are formed on leaves and stalks. Remove and burn infected plant parts.

Colletotrichum orbiculare. **Anthracnose** on watermelon.

Colletotrichum orbiculare (formerly *Colletotrichum lagenarium*). **Melon Anthracnose** on muskmelon, watermelon, cucumber, and other cucurbits. This is our most destructive disease of watermelons, found everywhere that melons are grown and particularly destructive in the South. There are at least three races of the fungus differing in ability to infect different cucurbits. One race is virulent on cucumber, slight on watermelon, moderate on Butternut squash; another is virulent on both watermelon and cucumber; Butternut squash is immune to a third.

Leaf symptoms are small yellow or water-soaked areas, which enlarge and turn black on watermelon, brown on muskmelon and cucumber. The dead tissue shatters; leaves shrivel and die. Elongated, narrow, sunken lesions appear on stems and petioles; vines may die. Young fruit darkens, shrivels and dies if pedicels are infected; older fruit shows circular, black, sunken cankers or depressions, from 1/4 to 2 inches across and 1/3 inch deep on watermelon. In moist weather the centers of such spots are covered with gelatinous masses of salmon-colored spores. Infected fruit has a bitter taste or the flesh is tough and insipid. Soft rots often follow the anthracnose. Epiphytotics occur only in periods of high rainfall and temperature, near 75°F.

Control. Treating seed before planting is essential. Use a three year crop rotation with non-cucurbits; destroy plant refuse. Watermelon varieties Charleston Gray, Congo, Fairfax, and Black Kleckly are resistant but not to all races of the fungus.

Colletotrichum phomoides (► *Glomerella cingulata*).**Tomato Anthracnose**, common rot of ripe tomatoes, most frequent in Northeast and North Central districts. Symptoms appear late in the season, causing more loss to canning crops. Small, circular sunken spots, increasing to an inch in diameter, penetrate deeply into the flesh. At first water-soaked, the spots turn dark, with pinkish, cream, or brown spore masses in the depressed centers, often arranged in concentric rings. The disease is worse in warm, moist weather. The fungus winters in tomato refuse, sometimes in cucumber and melon debris.

Control. Clean up trash and rotting fruit.

Colletotrichum pisi (► *Glomerella cingulata*). **Pea Anthracnose**, **Leaf and Pod Spot** commonly associated with Ascochyta blight and often a secondary parasite.

Colletotrichum schizanthi. **Anthracnose** on butterfly-flower. Symptoms are small brown spots on leaves and water-soaked areas on young stems. Cankers on stems and branches of older plants may cause leaves to turn yellow, branches to die back from the tip, and finally death of all parts above the canker.

Colletotrichum sublineola (see *Colletotrichum graminicola*). **Anthracnose** on wild rice (*Zizania*).

Colletotrichum trichellum. **Fruit Anthracnose** of tomato and Hedera.

Colletotrichum truncatum. **Stem Anthracnose** prevalent in the South on bean, lima bean, and soybean, also on clovers and on lentil in ND. Brick-red spots appear on veins on underside of leaves and on pods. Plants are chlorotic, stunted, may die prematurely; blossoms or pods may drop. Use healthy seed grown in arid states; clean up plant refuse; rotate with non-legumes.

Colletotrichum violae-tricoloris (► *Glomerella cingulata*). **Anthracnose** of violet, pansy.

Colletotrichum sp. **Azalea Anthracnose**. New disease serious on Indian and Kurume azaleas in Louisiana since 1954. Very small rusty brown spots appear on both surfaces of young leaves, followed by defoliation. Spores appear on fallen leaves, which serve as source of inoculum for the next season. Copper and organic fungicides are effective in control.

Discula

► Blights.

Discula campestris. **Anthracnose** on maple.
Discula destructive. **Anthracnose** on dogwood.
Discula fraxinea. (Teleomorph, **Gnomoniella fraxini**). **Anthracnose** on ash.

Gloeosporium

Deuteromycetes, Coleomycetes

Genus characters are about the same as for *Colletotrichum* except that there are no setae around the acervuli. Conidia are hyaline, one-celled, appearing in masses or pustules on leaves or fruit. Leaf spots are usually light brown, with foliage appearing scorched.

Gloeosporium allantosporum (► *Phlyctema vagabunda*). **Anthracnose**, **Dieback** on raspberry in Oregon, Washington.
Gloeosporium apocryptum (► *Glomerella cingulata*). **Maple Anthracnose**, **Leaf Blight**, an important leaf disease of silver maple, common also on other maples and boxelder, appearing from late May to August.
Gloeosporium aridum (**Discula fraxinea**). **Anthracnose** on ash.
Gloeosporium limetticolum (► *Glomerella cingulata*). **Lime Anthracnose**, **Withertip**, only on lime in southern Florida.
Gloeosporium melongenae (► *Glomerella cingulata*). (possibly identical with *G. piperatum*). **Eggplant Anthracnose**, **Ripe Rot**, an occasional trouble.
Gloeosporium piperatum (► *Glomerella cingulata*). **Pepper Anthracnose**, **Fruit Spot**, sometimes a leaf and stem spot but more often a disease of green or ripe fruit.
Gloeosporium quercinum (Telemorph, ► *Apiognomonia errabunda*). **Oak Anthracnose**. See *Discula umbrinella* and Fig. 3.2.
Gloeosporium thuemenii f. sp. **tulipi**. **Tulip Anthracnose** found in California in 1939. Lesions on peduncles and leaf blades of Darwin tulips are small to large, elliptical, first water-soaked then dry with black margins and numerous black acervuli in center of spots.
Gloeosporium sp.**Peony Anthracnose** on stems, leaves, flowers, petals of peony. Stem lesions are sunken, with pink spore pustules, and may complete-

ly girdle the stalks, causing death of plants. Also a destructive anthracnose on strawberry.

Glomerella

Ascomycetes, Phyllachorales

Perithecia are dark, hard, carbonaceous, usually beaked, immersed in substratum so only the neck protudes. Ascospores are hyaline, one-celled; asci are thickened at tips, inoperculate but spores sometimes discharged with force; paraphyses present.

Glomerella cingulata (formerly *Colletotrichum violae-tricoloris*). **Anthracnose** of violet, pansy. Circular dead spots with black margins, sometimes zonate, appear on leaves; flowers have petals spotted or not fully developed and producing no seed; entire plants are sometimes killed. Remove and burn infected plants or parts; clean up old leaves in fall. Copper sprays may be injurious.

Glomerella cingulata (formerly *Colletotrichum gloeosporioides*). **Anthracnose**, **Canker**, **Dieback**, **Withertip**, **Fruit Rot** of a great many plants, generally distributed except on the Pacific Coast, more common in the South. Infection is often secondary, in tissues weakened from other causes. See also under Canker and under Rots.

On citrus, orange, lemon, grapefruit there is a dying back or withertip of twigs. Leaf spots are light green turning brown, with pinkish spore pustules prominent in wet weather. Decayed spots are produced on ripening fruits in storage. Similar withertip symptoms may also appear on avocado, aucuba, cherimoya, fig, loquat, roselle, rosemallow, royal palm, dieffenbachia, rubber-plant, strawberry and other ornamentals and fruits. The disease has also been reported on European white birch in Virginia. Lack of water and nutrient deficiency predispose plants to infection by this weak parasite.

The fungus attacks blue lupine and statice or sea-lavender; peach anthracnose became important in Georgia when lupine was used as a ground cover in orchards. Sweet pea anthracnose is often more severe near apple orchards where the fungus winters on cankered apple limbs and in bitter rot mummies. Whitish lesions disfigure sweet pea leaves, shoots, and flower stalks. Leaves wither and fall; stalks dry up before blossoming; seed pods shrivel. There may be general wilting and shoot dieback.

Anthracnose and twig blight are widespread on privet. Leaves dry and cling to the stem; cankers at the base of stems are dotted with pink pustules. Bark turns brown and splits; death follows complete girdling of stems. European privet is highly susceptible; California, Amur, Ibota, and Regal privets are fairly resistant. Also found on black locust in GA and SC and pecan in GA.

Control. Remove infected twigs and branches from trees and shrubs, taking care to make smooth cuts at base of limbs and painting surfaces with a wound dressing. Plant sweet peas, from healthy pods, at a distance from apple and privet, in clean soil; rake up and burn plant refuse at the end of the season.

Glomerella cingulata (formerly *Gloeosporium melongenae*). (possibly identical with *G. piperatum*). **Eggplant Anthracnose Ripe Rot**, an occasional trouble. Yellow to brown spots on leaves and small to medium depressed spots on fruit show pink spore masses following rain or heavy dew. Spores are splashed by rain and spread by tools, insects, and workmen. Rotation of crops and sanitary measures may be sufficient control.

Glomerella cingulata (formerly *Gloeosporium limetticolum*). **Lime Anthracnose Withertip**, only on lime in southern Florida. Shoots, leaves, and fruits are infected when young; mature tissues are immune. Twigs wither and shrivel from one inch to several inches back from the tip; young leaves have dead areas or are distorted; buds fail to open and may drop; fruits drop, or are misshapen, or have shallow spots or depressed cankers.

Control. Spray with bordeaux-oil emulsion as fruit is setting, with two or three applications of 1 to 40 lime sulfur at 7–14 day intervals.

Glomerella cingulata (formerly *Gloeosporium apocryptum*). **Maple Anthracnose Leaf Blight**, an important leaf disease of silver maple, common also on other maples and boxelder, appearing from late May to August. The leaf spots are light brown, often merging with the leaves, appearing scorched. The effect may be confused with the physiological scorch caused by hot weather. On Norway maples the leaf lesions are confined to purple to brown lines along the veins. In rainy seasons there may be severe defoliation.

Control. If trees have been affected more than a year or so, feed to stimulate vigorous growth. Spray with a copper fungicide two or three times at 14-day intervals, starting when buds break open.

Glomerella cingulata (formerly *Colletotrichum bletiae*) and other species. **Orchid Anthracnose Leaf Spot** on orchids coming in from the tropics. Lemon-colored acervuli are formed in soft, blackish spots in ragged leaves. Burn diseased plants or parts. Spray with a copper fungicide.

Glomerella cingulata (formerly *Colletotrichum pisi*). **Pea Anthracnose Leaf and Pod Spot** commonly associated with Ascochyta blight and often a secondary parasite. Spots on pods, stems, and leaves are sunken, gray, circular, with dark borders. Crop rotation is the best control.

Glomerella cingulata (formerly *Gloeosporium piperatum*). **Pepper Anthracnose**, **Fruit Spot**, sometimes a leaf and stem spot but more often a disease of green or ripe fruit. Spots are dark, sunken, with concentric rings of acervuli and pink masses of spores, which are washed to other fruit. Seed is infected internally and contaminated externally. Harvest seed only from healthy fruit.

Glomerella cingulata (formerly *Colletotrichum erumpens*). **Rhubarb Anthracnose**, **Stalk Rot**. Oval, soft watery spots on petioles increase until whole stalks are included; leaves wilt and die. Small dark fruiting bodies with setae survive winter in stems, produce conidia in spring. Clean up all rhubarb remains in fall.

Glomerella cingulata (formerly *Colletotrichum antirrhini*). **Snapdragon Anthracnose** on snapdragon, chiefly in greenhouses, sometimes outdoors in late summer. Stems have oval, sunken spots, grayish white with narrow brown or reddish borders, fruiting bodies showing as minute black dots in center. Spots on leaves are circular, yellow green turning dirty white, with narrow brown borders. Stem cankers may coalesce to girdle plant at base, causing collapse of upper portions, with leaves hanging limp along the stem.

Control. Take cuttings from healthy plants; provide air circulation; keep foliage dry; destroy infected outdoor plants in autumn. Spray, every 7 to 10 days.

Glomerella cingulata (formerly *Colletotrichum phomoides*). **Tomato Anthracnose**, common rot of ripe tomatoes, most frequent in Northeast and North Central districts. Symptoms appear late in the season, causing more loss to canning crops. Small, circular sunken spots, increasing to an inch in diameter, penetrate deeply into the flesh. At first water-soaked, the spots turn dark, with pinkish, cream, or brown spore masses in the depressed centers, often arranged in concentric rings. The disease is worse in warm, moist weather. The fungus winters in tomato refuse, sometimes in cucumber and melon debris.

Control. Clean up trash and rotting fruit.

Glomerella glycines, **Fruit Anthracnose** of tomato. Also, anthracnose on soybean.

Glomerella gossypii, **Fruit Anthracnose** of tomato. Also, anthracnose on cotton.

Glomerella lindemuthianum (formerly *Colletotrichum lindemuthianum*). **Bean Anthracnose**, a major bean disease, sometimes mistakenly called "rust," generally present in eastern and central states, rare from the Rocky Mountains to the Pacific Coast. It may also affect lima bean, Scarlet runner, tepary, mung, kudzu, and broad beans, and cowpea. It is worldwide in distribution, known in the United States since 1880. There are at least 34 strains of the fungus, in three different groups, but the disease has decreased in importance with the use of western-grown, anthracnose-free seed.

The most conspicuous symptoms are on the pods, small, brown specks enlarging to black, circular, sunken spots, in moist weather showing the typical pinkish ooze of the slime-spores. Older spots often have narrow reddish borders. After the spores are washed away, the acervuli look like dark pimples. If pods are infected when young, the disease extends through to the seed, which turns yellow, then rusty brown or black under the pod lesion. The infection may extend deep enough to reach the cotyledons. Leaf lesions are dark areas along veins on underside of the blade and on petioles. Seedlings may show stem spotting below diseased cotyledons. The fungus is spread by splashing rain, tools, and gardeners working with beans when they are wet. Optimum temperature is between 63° and 75°F, with maximum around 85°F.

Control. Use western-grown seed. Saving home-grown seed is dangerous unless you can be sure of selecting from healthy plants and pods. Clean up, or spade under, old bean tops; rotate crops. Never pick or cultivate beans when vines are wet. There are some resistant varieties, but more reliance should be placed on obtaining seed grown where the disease is not present.

Glomerella nephrolepidis. **Fern Anthracnose**, **Tip Blight** of Boston and sword ferns. The soft growing tips of fronds turn brown and dry. Keep foliage dry; remove and burn diseased leaves.

Gnomonia

Ascomycetes, Diaporthales

Perithecia innate, beaked, separate; paraphyses absent; ascospores two-celled, hyaline; anamorph state *Gloeosporium* or *Marssonina*. Diseases caused by *Gnomonia* are classified as anthracnose, scorch, or leaf spot.

Gnomonia caryae. **Hickory Anthracnose**, **Leaf Spot**, widespread. The disease is common in eastern states, causing defoliation in wet seasons.

Large, roundish spots are reddish brown on upper leaf surface, dull brown underneath. The fruiting bodies are minute brown specks, and the fungus winters in dead leaves on the ground.

Gnomonia leptostyla (*Marssonina juglandis*). **Walnut Anthracnose**, **Leaf Spot**, general on butternut, hickory, and walnut. Spring infection comes from ascospores shot from dead leaves on the ground, secondary infection from conidia. Irregular dark brown spots appear on leaflets in early summer; if these are numerous, there is defoliation. An unthrifty condition of black walnuts and butternuts is often due to anthracnose.

Microdochium

Deuteromycetes, Coelomycetes

Hyaline, two-celled spores are formed in acervuli without setae. Spores are rounded at ends and are formed in pale to black masses on leaves.

Microdochium panattonianum (formerly *Marssonina panattoniana*). **Lettuce Anthracnose**. Small, dead, brown spots appear on blades and petioles, centers often falling out leaving black margined shot holes. Spots progress from older to young inner leaves; outer leaves are broken off and blown around by wind. The disease is important only during prolonged periods of wet weather, when it may cause heavy losses. Sanitary measures and treating seed before planting suffice for control.

Monographella

Ascomycetes, Dothideales

Perithecia immersed in substratum, not beaked, not setose, paraphyses lacking; spores hyaline, two-celled. The genus contains more than 1000 species, many destructive to plants, with conidial stages in many genera.

Monographella opuntiae (formerly *Mycosphaerella opuntiae*). **Cactus Anthracnose** on Cereus, Echinocactus, Mammillaria, and Opuntia. The curved spores of the anamorph state (*Microdochium lunatum*) form light pink pustules on the surface of moist, light brown rotten areas. Cut out and destroy diseased segments.

Pezicula

Ascomycetes, Helotiales

This is one of the discomycetes, cup fungi. The apothecia, formed on living plants, are fleshy, bright-colored with a peridium of dark cells forming a pseudoparenchyma. Spores are hyaline, fusoid.

Pezicula malicorticis (formerly *Neofabraea malicorticis*). **Northwestern Apple Anthracnose** on apple, crabapple, pear, quince, chiefly in the Pacific Northwest, where it is a native disease, serious in regions with heavy rainfall. Cankers are formed on younger branches – elliptical, dark, sunken, up to 3 or 4 inches wide and 10 to 12 inches long, delimited when mature by a crack in the bark. Conidia of the anamorph state (*Gloeosporium malicorticis*) are formed in cream-colored cushions, which turn black with age, in slits in the bark. Young cankers, reddish brown, circular spots appear on the bark in late fall. Fruit is infected, usually through lenticels from either ascospores or conidia in pustules on bark, but the disease may not show up until the apples are in storage.

Control. Cut out diseased limbs or excise cankers, burning all prunings and dead bark. Spray with bordeaux mixture before fruit is picked and fall rains start; repeat after harvest, and again about 2 weeks later.

Phlyctema

Deuteromycetes, Coleomycetes

Pycnidia dark, separate or sometimes cofluent, developing in or under the epidermis or bark. Conidiophores simle or forked; conidia hyaline, 1-celled, cylindrical or log, spindle-shaped, mostly bent.

Phlyctema vagabunda (formerly *Gloeosporium allantosporum*). **Anthracnose**, **Dieback** on raspberry in Oregon, Washington. See *Elsinoë veneta* under Spot Anthracnose for the common raspberry disease called anthracnose.

Pseudopeziza

Ascomycetes, Helotiales

Apothecia brown, cup-shaped, arising from leaves on short stalks, not setose, paraphyses present; spores one-celled, hyaline, ovoid.

Drepanopeziza ribis (formerly *Pseudopeziza ribis*). **Current Anthracnose**, **Leaf, Stem and Fruit Spot** generally distributed on currant, flowering currant, and gooseberry, first reported on black currants in Connecticut in 1873. Very small, brown, circular spots appear first on lower, older leaves, which turn yellow if spots are numerous. Hyaline, crescent-shaped conidia are formed in moist, flesh-colored masses in center of spots. In severe infections there is progressive defoliation from below upward.

Other occasional symptoms are black, sunken spots on leaf stalks, light brown to pale yellow lesions on canes, and black flyspeck spots on green berries, with considerable reduction in yield. Apothecia are formed on fallen leaves; ascospores are forcibly discharged in spring and carried by wind to young leaves.

Control. Clean up and burn old leaves under the bushes. Spray with bordeaux mixture (preferred to the newer organics) shortly after leaves appear (about 3 weeks after blossoming) and immediately after picking. Include a good spreader and cover both leaf surfaces thoroughly.

Pseudopeziza ribis (see *Drepanopeziza ribis*). **Current Anthracnose**, **Leaf, Stem and Fruit Spot** generally distributed on currant, flowering currant, and gooseberry, first reported on black currants in Connecticut in 1873.

BACTERIAL DISEASES

Rhizobiaceae

Agrobacterium

Small, motile, short rods, with two to six peritrichous flagella or a polar or subpolar flagellum, ordinarily Gram-negative, not producing visible gas or detectable acid in ordinary culture media; growth on carbohydrate media usually accompanied by copious entracellular, polysaccharide slime; gelatin liquefied slowly or not at all; optimum temperatures 25° to 30°C. Found in soil, or plant roots in soil, or in hypertrophies or galls on roots or stems of plants.

Agrobacterium rhizogenes. **Hairy Root** of apple, also recorded on cotoneaster, hollyhock, honey locust, honeysuckle, mulberry, peavine, peach, quince, Russian olive, rose, and spirea. "Woolly root" and "woolly knot" are other names given to this disease, which was long considered merely a form of crown gall. Both diseases may appear on the same plant and in early stages be confused. In hairy root a great number of small roots protrude either directly from stems or roots or from localized hard swellings that frequently occur at the graft union. The disease is common on grafted nursery apple trees 1, 2, or 3 years old, and the root development may be as profuse as witches' brooms. Control measures are the same as for crown gall.

Agrobacterium rubi. **Cane Gall** of brambles, on blackberry, black and purple raspberries, and, very rarely, red raspberry. Symptoms appear on fruiting canes in late May or June as small, spherical protuberances or elongated ridges of white gall tissue, turning brown after several weeks. Canes often split open and dry out; produce small seedy berries. Cane gall is not as important as crown gall, but one should use the same preventive measures. Avoid runner plants from infected mother plants.

Agrobacterium tumefaciens. **Crown Gall** on a great variety of plants in more than 40 families, general on blackberry, raspberry, and other brambles,

Figure 3.3 Crown Gall on Rose

on grapes and on rose (see Fig. 3.3); on fruit trees – apple, apricot, cherry, fig, peach and nectarine, pear (rarely), plum; on nuts – almond very susceptible, walnut fairly susceptible, pecan occasionally; on shade trees, willow and other hard woods; rare on conifers but reported on incense cedar and juniper; on many shrubs and vines, particularly honeysuckle and euonymus; on perennials such as asters, daisies, and chrysanthemums; and on beets, turnips, and a few other vegetables, with tomato widely used in experiments. Crown gall was first noticed on grape in Europe in 1853, and the organism was first isolated in 1904 in the United States from galls on Paris daisy. It is of first importance as a disease of nursery stock, but may cause losses of large productive trees in neglected orchards, especially almonds and peaches in California and other warm climates. It is very important to rose growers and to the amateur gardeners who sometimes receive infected bushes.

Symptoms. The galls are usually rounded, with an irregular rough surface, ranging up to several inches, usually occurring near the soil line, commonly at the graft union, but sometimes on roots or aerial parts. On euonymus, galls are formed anywhere along the vine. This is primarily a disease of the parenchyma, starting with a rapid proliferation of cells in the meristematic tissue and the formation of more or less convoluted soft or hard overgrowths or tumors. The close analogy of the unorganized cell growth of plant galls to wild cell proliferation in human cancer has intrigued scientists for many years. In some fashion bacteria provide stimulus for this overdevelopment, but similar galls have been produced on plants experimentally by injecting a virus or growth-promoting substances.

Entrance of bacteria into plants for natural infection is through wounds. In nurseries and orchards nematodes, the plow, the disc, or the hoe may be responsible; on the propagating bench grafting tools are indicted. Many claims have been made for the longevity of crown gall bacteria in soil, but it now seems to be established that they do not live in the absence of host plants more than a couple of years, and that sudden outbreaks of crown gall on land not previously growing susceptible crops are due to irrigation water bringing in viable bacteria from other infected orchards. The addition of lime to the soil may encourage crown gall, for bacteria do not live in an acid medium. The period of greatest activity is during the warm months.

Control. For home gardens rigid exclusion of all suspected planting stock is the very best control. Do not accept from your nurseryman blackberries, raspberries, roses, or fruit trees showing suspicious bumps. If you have had previous trouble, choose a different location for new, healthy plants. Be careful not to wound stems in cultivating.

For nurserymen, sanitary propagating practices are a must. Stock should be healthy. Grafting knives should be sterilized by frequent dipping in 10% Chlorox solution, 1 ounce in 2 gallons of water, or in denatured alcohol. If nursery soil is infested, 2 years' growth of cowpeas, oats, or crotalaria between crops will minimize crown gall.

Fruit and nut growers can perhaps plant less susceptible varieties, although fruit that is resistant in one locality may be diseased in another. American grape varieties are considered more resistant than European. Apples may be better on mahaleb root-stock, nut trees on black walnut understock. Budding rather than grafting reduces the chance of infection.

Painting galls with a solution of Elgetol-methanol has given control of crown gall on peaches and almonds in California. One part Elgetol (sodium dinitrocresol) is shaken with 4 parts synthetic wood alcohol and applied with a brush, covering the surface of the gall and extending 1/2 inch to 1 inch beyond the margin into healthy bark.

Coryneform Group Mycobacteriaceae

Clavibacter

Slender, straight to slightly curved rods, with irregularly stained segments or granules, often with pointed or club-shaped swellings at ends; nonmotile with a few exceptions (*C. flaccumfaciens* and *C. poinsettiae*). Gram-positive.

Clavibacter agcopyri (see *Corynebacterium agcopyei*). **Yellow Gum Disease** on western wheat grass.

Clavibacter fascians (see *Rhodococcus fascians*). **Fasciation**, widespread on sweet pea, also on carnation, chrysanthemum, gypsophila, geranium, petunia,impatiens, *Hebe* sp. and pyrethrum.

Clavibacter flaccumfaciens (see *Curtobacterium flaccumfaciens* pv. *flaccumfaciens*). **Bacterial Wilt** of bean, widespread on kidney and lima beans and soybean, causing considerable loss.

Clavibacter humiferum (see *Corynebacterium humiferum*). Reported from wetwood of poplar, in Colorado.

Clavibacter michiganense (see *Clavibacter michiganense* subsp. *michiganense*). **Bacterial Canker** of Tomato, widespread, formerly causing serious losses of tomato canning crops.

Clavibacter michiganense subsp. **michiganense** (formerly *Clavibacter michiganens*). **Bacterial Canker** of Tomato, widespread, formerly causing serious losses of tomato canning crops. The disease has now been reported on browallia, brunfelsia, cestrum, *Datura* sp., eggplant, Jerusalem-cherry, bittersweet, pepper, painted-tongue, potato, ground-cherry, and butterfly-flower in Wyoming. This is a vascular wilt disease, seedlings remaining stunted. Symptoms on older plants start with wilting of margins of lower leaflets, often only on one side of a leaf. Leaflets curl upward, brown, and wither, but remain attached to stem. One-sided infection may extend up through the plant and open cankers from pith to outer surface of stem. Fruit infection starts with small, raised, snow-white spots, centers later browned and roughened but the white color persisting as a halo to give a bird's-eye spot. Fruits can be distorted, stunted, yellow inside. In the field, bacteria are spread by splashed rain and can persist in soil 2 or more years. Seeds carry the bacteria internally as well as externally.

Control. Use certified seed, a 2- or 3-year rotation; clean up tomato refuse at end of season and diseased plants throughout season. Fermenting tomato pulp for 4 days at a temperature near 70°F will destroy bacteria on surface of seed; hot-water treatment, 25 minutes at 122°F will kill some, perhaps not all, of internal bacteria. Start seedlings in soil that has not previously grown tomato.

Clavibacter poinsettiae (see *Curtobacterium flaccumfaciens* pv. *poinsettia*). **Stem Canker** and **Leaf Spot** of Poinsettia, a relatively new disease, first noted in greenhouses in 1941.

Clavibacter sepedonicum (see *Clavibacter michiganense* subsp. *sepedonicum*). **Bacterial Ring Rot** of potato, widespread since 1931, when it probably was introduced from Europe.

Clavibacter michiganense subsp. sepedonicum (formerly *Clavibacter sepedonicum*). **Bacterial Ring Rot** of potato, widespread since 1931, when it probably was introduced from Europe. All commercial varieties are susceptible, with losses formerly in millions of dollars in decay of tubers in field and storage. Now a single infected plant in a potato field disqualifies the whole field for certification. Symptoms appear when plants are nearly full grown, with one or more stems in a hill wilted and stunted while the rest seem healthy. Lower leaves have pale yellow areas between veins; these turn deeper yellow, and margins roll upward. A creamy exudate is expelled when the stem is cut across. This bacterium may also occur in sugar beet which are symptomless.

Tuber infection takes place at the stem end, and the most prominent symptoms appear some time after storage. The vascular ring turns creamy yellow to light brown, with a crumbly or cheesy odorless decay followed by decay from secondary organisms. Bacteria are not spread from plant to plant in the field, but by cutting knife and fingers at planting. A knife used to cut one infected tuber may contaminate the next 20 seed pieces.

Control. Use certified seed potatoes. Use several knives and rotate them in disinfestant. Commercial growers use a rotating knife passed through a chemical or hot-water bath between cuts. Disinfest tools, grader, digger, and bags; sweep storage house clean and spray with copper sulfate, 1 pound to 5 gallons of water.

Clavibacter xyli subsp. **cynodontis**. **Stunting Disease** of bermudagrass.

Clavibacter xyli subsp. **xyli**. **Ratoon Stunt** of sugarcane.

Corynebacterium agropyri (formerly *Clavibacter agropyri*). **Yellow Gum Disease** on western wheat grass. Enormous masses of surface bacteria form yellow slime between stem and upper sheath and glumes of flower head; plants dwarfed or bent; normal seeds rare.

Corynebacterium humiferum (formerly *Clavibacter humiferum*). Reported from wetwood of poplar, in Colorado.

Curtobacterium flaccumfaciens pv. flaccumfaciens (formerly *Clavibacter flaccumfaciens*). **Bacterial Wilt of Bean**, widespread on kidney and lima beans and soybean, causing considerable loss. Plants wilt at any stage from seedling to pod-production, with leaves turning dry, brown, and ragged after rains. Plants are often stunted. Bacteria winter on or in seed, which appear yellow or wrinkled and varnished. When infected seed is planted, bacteria pass from cotyledons into stems and xylem vessels. Other plants are infected by mechanical injury and perhaps by insects, but there is not much danger from splashed rain. Plants girdled at nodes may break over.

Control. Use seed grown in Idaho or California.

Curtobacterium flaccumfaciens pv. poinsettia (formerly *Clavibacter poinsettiae*). **Stem Canker** and **Leaf Spot** of Poinsettia, a relatively new disease, first noted in greenhouses in 1941. Longitudinal water-soaked streaks appear on one side of green stems, sometimes continuing through leaf petioles to cause spotting or blotching of leaves and complete defoliation. The cortex of stems turns yellow, the vascular system brown. Stems may crack open and bend down, with glistening, golden brown masses of bacteria oozing from stem ruptures and leaf lesions.

Control. Discard diseased stock plants; place cuttings from healthy mother plants in sterilized media; avoid overhead watering and syringing; rogue suspicious plants promptly.

Rhodococcus fascians (formerly *Clavibacter fascians*). **Fasciation**, widespread on sweet pea, also on carnation, chrysanthemum, gypsophila, geranium, petunia,impatiens, *Hebe* sp. and pyrethrum. Sweet pea symptoms are masses of short, thick, and aborted stems with misshapen leaves developing near the soil line at first or second stem nodes. The fasciated growth on old plants may have a diameter of 3 inches but does not extend more than an inch or two above ground. The portion exposed to light develops normal green color. Plants are not killed, but stems are dwarfed and blossom production is curtailed.

Control. Sterilize soil or use fresh.

Rickettsialike bacteria. **Bacterial Wilt** on Toronto creeping bentgrass; bacteria found in xylem of roots, crown, and leaves. Initially, leaf blades wilt from tip down and within several days entire leaf wilts, becomes dark green, shriveled, and twisted; also leaf scorch of mulberry.

Enterobacteriaceae

Erwinia

Motile rods (usually) with peritrichous flagella; Gram-negative; producing acid with or without visible gas from a variety of sugars; invading tissues of living plants producing dry necroses, galls, wilts, and soft rots. The genus is named for Erwin F. Smith, pioneer in plant diseases caused by bacteria.

Enterobacter cloacae. **Bulb Decay** on onion.

Erwinia amylovora. **Fire Blight**, general on many species in several tribes of the Rosaceae, particularly serious on apple, pear, and quince. Other hosts include almond, amelanchier, apricot, aronia, blackberry, cherry, chokecherry, cotoneaster, crabapple, exochorda, geum, hawthorn, holodiscus, India hawthorn, kerria, Japanese quince, loquat, medlar, mountain-ash, plum, photinia, pyracantha, raspberry, rose, spirea, and strawberry.

Apparently a native disease, first noticed near the Hudson River in 1780, fire blight spread south and west with increased cultivation of pears and apples. By 1880 it had practically wrecked pear orchards in Illinois, Iowa, and other states in the Northern Mississippi Valley. Then it devastated pears on the Texas Gulf. Reaching California by 1910 it played havoc up the coast to Washington.

Symptoms. Blossoms and leaves of infected twigs suddenly wilt, turn dark brown to black, shrivel and die, but remain attached to twigs (see Fig. 3.4). The bark is shrunken, dark brown to purplish, sometimes blistered with gum oozing out. Brown or black blighted branches with dead persistent leaves look as if scorched by fire. The bacteria survive the winter in living tissue at the edge of "holdover cankers" on limbs. These are dead, slightly sunken areas with a definite margin or slight crack where dead tissue has shrunk away from living. In moist weather bacteria appear on the surface of cankers in pearly viscid drops of ooze, which is carried by wind-blown rain or insects to blossoms. Infection spreads from the blighted bloom to the young fruit, then down the pedicel to adjacent leaves, which turn brown, remaining hang-

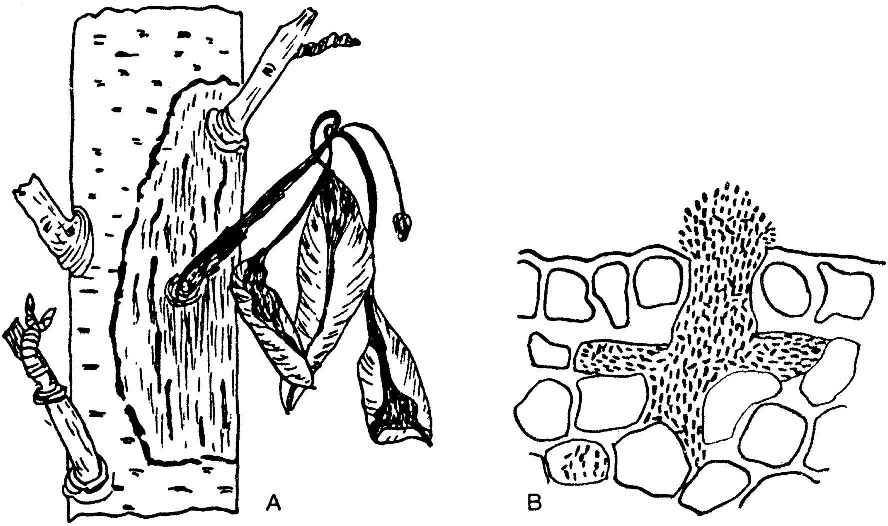


Figure 3.4 Fire Blight. **A** hold over canker developed on apple limb at base of blighted twig; **B** bacteria swarming through tissue

ing around the blighted blossom cluster. Leaf and fruit blight is also possible by direct invasion, a secondary infection via bacteria carried from primary blossom blight by ants, aphids, flies, wasps, fruit-tree bark beetles, and honeybees, sometimes tarnished plant bugs, and pear psyllids.

The tissue first appears water-soaked, then reddish, then brown to black as the bacteria swarm between the dying parenchyma cells. Division may take place every half hour; so they multiply rapidly and are usually well in advance of discolored external tissue. A collar rot may develop when cankers are formed near the base of a tree. Water sprouts are common sources of infection.

As spring changes to summer, the bacteria gradually become less active and remain dormant at the edge of a woody canker until the next spring at sap flow. Ordinarily they do not winter on branches smaller than 1/2 inch in diameter.

Control. Spraying during bloom is now a standard means of preventing blossom blight. Use bordeaux mixture or a fixed copper or streptomycin at 60 to 100 ppm. The latter is very effective at relatively high temperatures; at 65°F and below, copper is more satisfactory. Start spraying when about 10% of the blossoms are open and repeat at 5- to 7-day intervals until late bloom is over. A dormant spray for aphid control helps in preventing fire blight. One or more sprays may be needed for leafhoppers, starting at petal fall.

Inspect trees through the season and cut or break out infected twigs 12 inches below the portion visibly blighted. If lesions appear on large limbs they may be painted with one of the following mixtures:

I. 1 quart denatured alcohol, 1/4 pint distilled water, 3/4 ounce muriatic acid, 1 1/2 pounds zinc chloride.
II. 100 grams cobalt nitrate, 50 cc glycerine, 100 cc oil of wintergreen, 50 cc acetic acid, 80 cc denatured alcohol.
III. 5 parts cadmium sulfate stock solution (1 pound stirred into 2 pints warm water), 2 parts glycerine, 2 parts muriatic acid, 5 parts denatured alcohol.

Formulas I and II were developed for use on the West Coast, III for New York. The paint is brushed on the unbroken bark over the lesions and for several inches above and below the canker; it may injure if there are wounds or cuts.

In cutting out cankered limbs during the dormant season, take the branch off at least 4 inches back from edge of the canker, and disinfect the cut. The home gardener may want to use 10% Chlorox for tools and bordeaux paint for cut surfaces. Dry bordeaux powder is stirred into raw linseed oil until a workable paste is formed.

Almost all desirable pear varieties are susceptible to fire blight, particularly Bartlett, Flemish Beauty, Howell, Clapps Favorite. Varieties Old Home, Orient, and the common Kieffer are more or less resistant. Jonathon apples are very susceptible. Less apt to be severely blighted are Baldwin, Ben Davis, Delicious, Duchess, McIntosh, Northern Spy, Stayman, and Winter Banana.

At the University of California some work has been done on susceptibility of ornamentals to fire blight. *Pyracantha angustifolia* is quite susceptible, but *P. coccinea* and *P. crenulata* are rather resistant. *Cotoneaster salicifolia* is susceptible; *C. dammeri, C. pannosa*, and *C. horizontalis* are more resistant; and *C. adpressa* and *C. microphylla* show marked resistance.

Cultural methods influence the degree of fire blight, which is worse on fast-growing succulent tissue. Avoid heavy applications of nitrogen fertilizers; apply such nitrogen as is required in autumn or in spring in foliar sprays after danger of blossom blight is over.

Erwinia carnegieana. **Bacterial Necrosis** of giant cactus in the entire habitat of *Carnegia gigantea*. Long present in southern Arizona, this disease was not described until 1942, after it had encroached on cactus parks and private estates. Many giant cacti in the Saguaro National Monument have been killed, with heaviest mortality in trees 150 to 200 years old.

Symptoms start with a small, circular, light spot, usually with a water-soaked margin. The tissues underneath turn nearly black; the spot enlarges and has a purplish hue with the center cracking and bleeding a brown liquid. The rotten tissues dry, break up into granular or lumpy pieces, and fall to the ground. Rotting on one side means leaning to that side; when the trunk is girdled near the base, the giant is likely to fall in a wind-storm. If it does not break, it stands as a bare, woody skeleton, with all parenchyma tissue disintegrated. An insect, *Cactobrosis fernaldialis*, is largely responsible for the rapid spread of the disease. The larvae tunnel inside the stems most of the year, emerging from May to August to pupate for a month or so before the adult, a tan and brown nocturnal moth, lays eggs.

Control. A phosphate dust, applied monthly from April to September, has effectively controlled the insect vector. Incipient infections can be cut out and the cavity allowed to dry out and cork over. Before the insect vector was known, fallen trees were cut into short lengths, dragged to a burial pit, covered with a disinfectant, and then with soil.

Erwinia carotovora subsp. **carotovora** (formerly *Erwinia carotovora*). **Soft Rot** of calla, originally described from common calla, found on golden calla, and also on beet, cactus, cabbage, cauliflower, celery, cucumber, carrot, eggplant, geranium (*Pelargonium*), hyacinth, iris, onion, parsnip, pepper, potato, salsify, sansevieria, tobacco, tomato, and turnip.

On calla lily the soft rot starts in upper portion of the corm and progresses upward into leaf and flower stalks or down into roots, with the corm becoming soft, brown, and watery. Sometimes infection starts at edge of petiole, which turns slimy. Leaves with brown spots and margins die or rot off at the base before losing color. Flowers turn brown; stalks fall over; roots are soft and slimy inside the epidermis. Corms may rot so fast the plant falls over without other symptoms, or the diseased portion may dry down to sunken dark spots, in which the bacteria stay dormant to the next season.

On tomatoes, infection takes place through growth cracks, insect wounds, or sunscald areas. The tissue is at first water-soaked, then opaque, and in 3 to 10 days the whole fruit is soft, watery, colorless, with an offensive odor.

Control. Scrub calla corms, cut out rotted spots, and let cork over for a day or two. Plant in fresh or sterilized soil in sterilized containers and keep pots on clean gravel or wood racks, never on beds where diseased callas have grown previously. Grow at cool temperatures and avoid overwatering.

Erwinia carotovora subsp. **atroseptica** (formerly *Erwinia carotovora*). **Potato Blackleg**, **Basal Stem Rot**, **Tuber Rot**, general on potato. This is a systemic disease perpetuated by naturally infected tubers. Lower leaves turn yellow; upper leaves curl upward; stems and leaves tend to grow up rather than spread out; stem is black-spotted, more or less softened at base and up to 3 or 4 inches from ground, and may be covered with bacterial slime; shoots may wilt and fall over. Tubers are infected through the stem end. The disease is most rapid in warm, moist weather, and may continue in storage. The bacteria are spread on the cutting knife, as with ring rot, and by seed-corn maggots, and may persist for a time in soil.

Control. Use certified seed potatoes and plant whole tubers; if cut seed must be used, allow to cork over to prevent infection from soil. Practice long rotation; disinfest cutting knife. Late varieties seem to be more resistant.

Erwinia carotovora subsp. **atroseptica** (formerly *Erwinia carotovora*). **Delphinium Blackleg**, **Foot Rot**, **Bacterial Crown Rot** of perennial Delphinium; **Stem and Bud Rot** of Rocket Larkspur. In delphinium there is a soft black discoloration at the base of the stem, with bacteria oozing out from cracks. In larkspur there is a black rot of buds as well as yellowing of leaves, blackening of stem, stunting of plants. The bacteria are apparently carried in seed; hot-water treatment is helpful. Drenching delphinium crowns with bordeaux mixture has been recommended in the past. Insect larval control is helpful with potato. Avoid excessive watering or irrigation.

Erwinia carotovora subsp. **carotovora** (formerly *Erwinia carotovora* var. *carotovora*). **Wilt** of sunflower, Kalanchoë; zucchini squash, and draceana. **Soft Rot**, general on many vegetables, in field, storage, and transit, and many ornamentals, especially iris. The bacteria were first isolated from rotten carrots, whence the name, but they are equally at home in asparagus, cabbage, turnips and other crucifers, celery, cucumber, eggplant, endive, garlic, horseradish, melon, parsnip, pepper, spinach, sunflower (stalk rot), sweetpotato, and tomato. Besides wide distribution on iris, soft rot has been reported, among ornamentals, on chrysanthemum, dahlia, Easter lily, geranium, orchid, sansevieria, poinsettia, and yellow calla.

The bacteria enter through wounds, causing a rapid, wet rot with a most offensive odor. The middle lamella is dissolved, and roots become soft and pulpy. Soft rot in iris often follows borer infestation. Tips of leaves are withered, the basal portions wet and practically shredded. The entire interior of a rhizome may disintegrate into a vile yellow mess while the epidermis remains firm. The rot is more serious in shaded locations, when iris is too crowded or planted too deeply.

Control. Borer control, starting when fans are 6 inches high, has greatly reduced the incidence of rot. If it appears, dig up the clumps, cut away all rotted portions, cut leaves back to short fans. Allow to dry in the sun for a day or two, then replant in well-drained soil, in full sun with upper portion of the rhizome slightly exposed. Many good iris growers do not agree with this "sitting duck" method, preferring to cover with an inch of soil; but the sun is an excellent bactericide, and shallow planting is one method of disease control. Clean off all old leaves in late fall after frost.

Prevent rot on stored vegetables by saving only sound, dry tubers, in straw or sand, in a well-ventilated room with temperature not too much above freezing. In the garden, rotate vegetables with fleshy roots with leafy varieties. Avoid bruising at harvest time.

Erwinia chrysanthemi. **Bacterial Blight** of Chrysanthemum, a florists' disease, first noted in 1950. First evidence of blight is a gray water-soaked area mid-point on the stem, followed by rot and falling over. The diseased tissue is brown or reddish brown; the rot progresses downward to the base of the stem or, under unfavorable conditions, may be checked with axillary buds below the diseased area producing normal shoots. Cuttings rot at the base. Sometimes affected plants do not show external symptoms, and cuttings taken from them spread the disease. Bacteria can be spread via cutting knife, or fingernails in pinching, and can live several months in soil. A form of this species causes a leaf blight of philodendron and may also infect banana, carnation, corn, and sorghum and pith/stem rot of tomato.

Control. Snap off cuttings; sterilize soil and tools.

Corn rot. Corn leaves show light or dark brown rotting at base; husks and leaf blades have dark brown spots; lower portion of stalk is rotten, soft, brown, with strong odor of decay; plants may break over and die, with little left but a mass of shredded remnants of fibrovascular bundles. Bacteria enter through hydathodes (water pores), stomata, and wounds.

Erwinia cypripedii. Reported from California, causing brown rot of Cypripedium orchids. Small, circular to oval, water-soaked, greasy light brown spots become sunken, dark brown to chestnut. Affected crowns shrivel; leaves drop.

Erwinia herbicola (see *Pantoea herbicola*). **Leaf Spot** of dracaena.

On Dracaena sanderana, gypsophila and related plants.

Erwinia nimipressuralis. **Wetwood** of elm, slime flux, due to bacteria pathogenic in elm trunk wood, especially Asiatic elms, but possibly occurring in many other trees, including maple, oak, mulberry, poplar, and willow. A water-soaked dark discoloration of the heartwood is correlated with chronic bleeding at crotches and wounds and abnormally high sap pressure in trunk, with wilting a secondary symptom. The pressure in diseased trees increases from April to August or September, reaching 5 to 30 pounds per square inch (as much as 60 pounds in one record). The bacteria inhabit ray cells mostly and do not cause a general clogging of water-conducting tissues. This pressure, caused by fermentation of tissues by bacteria, causes fluxing, a forcing of sap out of trunks through cracks, branch crotches, and wounds. The flux flows down the trunk, wetting large areas of bark and drying to a grayish white incrustation. Bacteria and yeasts working in the flux cause an offensive odor that attracts insects.

Control. Bore drain holes through the wood below the fluxing wound, slightly slanted to facilitate drainage. Install 1/2-inch copper pipe to carry the dripping sap away from the trunk and buttress roots. Screw the pipe in only far enough to be firm; if it penetrates the water-soaked wood, it interferes with drainage.

Erwinia rhapontica. **Rhubarb Crown Rot**, similar to soft rot.

Erwinia stewartii (see *Pantoea stewartii*). **Bacterial Wilt** of corn, **Stewart's Disease** on sweet corn, sometimes field corn, in the middle regions of the United States, from New York to California.

Erwinia tracheiphila. **Bacterial Wilt** of cucurbits, **Cucumber Wilt** on cucumber, pumpkin, squash, and muskmelon but not watermelon. The disease is generally east of the Rocky Mountains and is also present in parts of the West; is most serious north of Tennessee. Total loss of vines is rare, but a 10 to 20% loss is common.

This is a vascular wound disease transmitted by striped and 12-spotted cucumber beetles. Dull green flabby patches on leaves are followed by sudden wilting and shriveling of foliage, and drying of stems. Bacteria ooze from cut stems in viscid masses. Partially resistant plants may be dwarfed, with excessive blooming and branching, wilting during the day but partially recovering at night. The bacteria winter solely in the digestive tract of the insects and are deposited on leaves in spring with excrement, entering through wounds or stomata.

Control is directed chiefly at the insects. Start vines under Hotkaps and spray or dust with rotenone or other insecticide when the mechanical protection is removed. Experimental spraying with antibiotics – streptomycin, terramycin, and neomycin has reduced wilt and increased yield.

Pantoea ananatis, **Leaf Blight** and **Bulb Decay** of onion.

Pantoea herbicola (formerly *Erwinia herbicola*). **Leaf Spot** of dracaena. On Dracaena sanderana, gypsophila and related plants. Galls are formed at crown and roots of grafted plants from 1/4 to 1 inch in diameter, but with a flat nodular growth rather than the usual globose crown gall.

Pantoea stewartii (formerly *Erwinia stewartii*). **Bacterial Wilt** of corn, **Stewart's Disease** on sweet corn, sometimes field corn, in the middle regions of the United States, from New York to California. This is a vascular disease with yellow slime formed in the water-conducting system, resulting in browning of nodes, and dwarfing of plants; or long pale green streaks on leaf blades, followed by wilting and death of whole plant. Tassels may be formed prematurely and die before the rest of the plant. The bacteria are chiefly disseminated by corn flea beetles, and winter either in the beetles or in seed. Primary infections come from flea beetles feeding in spring, from infected seed, and occasionally from soil; but secondary spread is mostly by insects.

Corn grown in rich soil is more susceptible to wilt, and so are early varieties, especially Golden Bantam. Winter temperatures influence the amount of wilt the following summer. If the winter index, which is the sum of mean temperatures for December, January, and February, is above 100, bacterial wilt will be present in destructive amounts on susceptible varieties. If the index is below 90, the disease will be very sparse in northeastern states; if the index is between 90 and 100, there will be a moderate amount of wilt. Disease surveys over a period of years testify to the reliability of such forecasts (based on the amount of cold the flea beetle vectors can survive); but with the increasing use of hybrid sweet corn resistant to wilt, the importance of winter temperatures is reduced.

Control. Use insecticides to control flea beetles; substitute commercial fertilizer for manure; destroy infected refuse; try treating seed with terracmycin or streptomycin. Use resistant varieties such as Golden Cross Bantam, Carmelcross, Ioana, Marcross, and Iochief.

Pseudomonadaceae

Pseudomonas

Motile with polar flagella; straight or curved rods; Gram-negative. Many species produce a greenish, water-soluble pigment. Many species are found in soil and water; many are plant pathogens causing leaf spots or blights.

Acidovorax avenae (formerly *Pseudomonas albopreciptans*). **Bacterial Spot** of cereals, grasses, and corn. Light or dark brown spots or streaks on grass blades. Bacteria enter through stomata or water pores.
Acidovorax avenae (formerly *Pseudomonas avenae*). **Bacterial Leaf Spot** of sweet corn. **Bacterial Leaf Blight** of johnsongrass.
Acidovorax avenae subsp. **citrulli** (formerly *Pseudomonas pseudoalcaligenes*). **Angular Leaf Spot** of muskmelon and watermelon. Fruit blotch; on melon, squash, pumpkin, and watermelon.
Acidovorax cattleyae (formerly *Pseudomonas cattleyae*). **Brown Spot** of orchids, *Phalaenopsis* and *Cattleya*, common in greenhouses. Infection is through stomata of young plants, wounds of older plants. Dark green, circular water-soaked spots change to brown and finally black. On *Cattleya* the disease is limited to older leaves.
Burkholderia andropogonis (formerly *Pseudomonas andropogonis*). **Bacterial Stripe** of sorghum and corn. **Bacterial Leaf Spot** on bougainvillea. **Black Spot** on clovers and statice. Also causes blight of chickpea, and bacterial leaf spot on white clover. Red streaks and blotches appear on leaves and sheaths, with abundant exudate drying down to red crusts or scales, readily washed off in rains. Bacteria enter through stomata.
Bacterial Leaf Spot of velvet bean, clovers. Translucent angular brown leaf spots have lighter centers and chlorotic surrounding tissue; there is no exudate. Bacteria enter through stomata and fill intercellular spaces of parenchyma.
Burkholderia caryophylli (formerly *Pseudomonas caryophylli*). **Bacterial Wilt** of carnation, usually under glass. Plants wilt, turn dry, colorless with roots disintegrating. Grayish-green foliage is the first symptom, but leaves rapidly turn yellow and die. Yellow streaks of frayed tissue in vascular areas extend a foot or two up the stem. It takes a month for disease to show up after inoculation, but it can be transmitted on cuttings taken from plants before appearance of symptoms. The sticky character of diseased tissue distinguishes this wilt from Fusarium wilt. Varieties Cardinal Sim, Laddie, Mamie, Portrait, and others may have severe cankers at base of stems, orange-yellow when young, very sticky. Bacteria are spread by hands, tools, splashing water. Also causes crown and leaf rot of statice.
Control. Remove and burn diseased plants and all within 1 1/2 -foot radius. After handling wash with hot water and soap, sterilize tools (10% Clorox for 5 minutes). Obtain rooted cuttings from propagators of cultured, disease-free material; keep in shipping bags until ready for benching and then place in

raised, steam-pasteurized benches. Never place cuttings in water or a liquid fungicide (use dust if a fungicide is required for other diseases); never place temporarily on an unsterilized table; never cut or trim with hands or knives; never plant in outdoor "nurse beds"; never use overhead watering.

Burkholderia cepacia (formerly *Pseudomonas cepacia*). **Sour Skin Rot** of onion. Slimy yellow rot of outer fleshy scales, with a vinegar odor. Let crop mature well before harvesting, tops dry before topping; cure bulbs thoroughly before storage.

Burkholderia gladioli (formerly *Pseudomonas gladioli*). **Leaf Spot** and **Blight** on bird's nest fern.

Onion Bulb Rot, a storage disease, inner scales of bulb water-soaked and soft, sometimes entire bulb rotting.

Orchid Brown Rot and **Leaf Spot**.

Gladiolus Scab, **Stem Rot**, **Neck Rot**, widespread on gladiolus, also on iris, bell peppers and tigridia. Lesions on corms are pale yellow, water-soaked circular spots deepening to brown or nearly black, eventually sunken with raised, horny, or brittle margins that are scablike and exude a gummy substance. Bacteria overwinter on corms. First symptoms after planting are tiny reddish raised specks on leaves, mostly near the base, enlarging to dark sunken spots, which grow together into large areas with a firm or soft rot. Sometimes plants fall over, but the disease is not ordinarily very damaging in the garden. The chief loss is to the grower in disfigured, unsalable corms. Brown streaks in husks sometimes disintegrate, leaving holes.

Gladiolus scab is increased by bulb mites, may be related to grub and wireworm injury.

Pseudomonas aceris (see *Pseudomonas syringae* pv. *aceris*). **Maple Leaf Spot** found in California on big leaf maple.

Pseudomonas adzukicola. **Stem Rot** of adzuki bean.

Pseudomonas albopreciptans (see *Acidovorax avenae*). **Bacterial Spot** of cereals, grasses, and corn.

Pseudomonas andropogonis (see *Burkholderia andropogonis*). **Bacterial Stripe** of sorghum and corn.

Bacterial Leaf Spot of velvet bean, clovers. Translucent angular brown leaf spots have lighter centers and chlorotic surrounding tissue; there is no exudate. Bacteria enter through stomata and fill intercellular spaces of parenchyma.

Pseudomonas angulata (see *Pseudomonas syringae* pv. *angulata*). **Blackfire** of tobacco.

Pseudomonas asplenii. **Bacterial Leaf Blight** of bird's-next fern, first reported from greenhouses in California. Small translucent spots enlarge to cover whole frond; bacteria may invade crown and kill whole plant. Control depends on strict sanitation – sterilizing flats, pots, media, and foreceps used in transplanting. Avoid excessive watering and too high humidity.

Pseudomonas avenae (see *Acidovorax avenae*). **Bacterial Leaf Spot** of sweet corn. **Bacterial Leaf Blight** of johnsongrass.

Pseudomonas berberidis. **Bacterial Leaf Spot** of barberry. Small, irregular, dark green water-soaked areas on leaves turn purple-brown with age; occasional spotting occurs on leaf stalks and young shoots. If twigs are infected, buds do not develop in the next season; if they are girdled, the entire twig is blighted. Cut out infected twigs and spray with bordeaux mixture or an antibiotic.

Pseudomonas caryophylli (see *Burkholderia caryophylli*). **Bacterial Wilt** of carnation, usually under glass.

Pseudomonas cattleyae (see *Acidovorax cattleyae*). **Brown Spot** of orchids, *Phalaenopsis* and *Cattleya*, common in greenhouses.

Pseudomonas cepacia (see *Burkholderia cepacia*). **Sour Skin Rot** of onion. Slimy yellow rot of outer fleshy scales, with a vinegar odor.

Pseudomonas cichorii. **Bacterial Leaf Spot** on basil. **Bacterial Blight** on Lobelia.

Pseudomonas cichorii. **Bacterial Rot** of chicory, Belgium endive, French endive, iris, **Soft Rot** of potato, and **Bacterial Leaf Spot** of hibiscus, geranium, magnolia and rhododendron. May also cause a **Leaf Spot** and **Stem Necrosis** on chrysanthemum (see Fig. 3.5) and **Bacterial Leaf Blight** on dwarf *Schefflera*. A yellowish olive center rot, affecting young inner leaves.

Pseudomonas corrugata. **Stem Rot** of tomato, also **Pith Necrosis**.

Pseudomonas fluorescens (*marginalis*). **Marginal Blight** of lettuce, **Kansas Lettuce Disease**, also on witloof chicory, **Soft Rot** of potato tubers. Leaf margins are dark brown to almost black, first soft, then like parchment. Yellowish red spots, turning dark, are scattered over leaves. Infected tissue disintegrates into an odorous mass. Bacteria live in the soil, which should not be splashed on plants by careless watering.

Pseudomonas gladioli (see *Burkholderia gladioli*). **Leaf Spot** and **Blight** on bird's nest fern.

Pseudomonas melophthora. **Apple Rot**, probably widespread. This is a decay of ripe apples following after apple maggots and eventually rotting whole fruit.

Figure 3.5 Bacterial Black Spot on Chrysanthemum

Pseudomonas pseudoalcaligenes (see *Acetovorax avenae* subsp. *citrulli*). **Angular Leaf Spot** of muskmelon and watermelon. **Fruit Blotch** on melon, squash, pumpkin, and watermelon.

Pseudomonas ribicola. On golden currant in Wyoming.

Pseudomonas sesami. **Bacterial Leaf Spot** of sesame. Brown spots on leaves and stems. Can be controlled by treating seed with streptomycin.

Pseudomonas solanacearum (see *Rolstonia solanacearum*). **Southern Bacterial Wilt**, also called **Brown Rot**, **Bacterial Ring Disease**, **Slime Disease**, **Granville Wilt** (of tobacco), present in many states but particularly prevalent in the South, from Maryland around the coast to Texas.

Pseudomonas syringae. **Canker** on kiwifruit; also **Blight** on impatiens and mock orange. Also **Leaf Spot** on English and American elm, mountain-laurel, arugula and coriander. **Stem Dieback** of Centaurea and fennel.

Pseudomonas syringae pv. **aceris** (formerly *Pseudomonas aceris*). **Maple Leaf Spot** found in California on big leaf maple. Small, water-soaked spots, surrounded by yellow zones, turn brown or black; cankers develop on petioles and bracts in serious cases; leaves may drop; disease present in cool, damp weather of early spring.

Pseudomonas syringae pv. **angulata** (formerly *Pseudomonas angulata*). **Blackfire** of tobacco.

Pseudomonas syringae pv. **apii**. **Bacterial Blight** of celery. Small, irregularly circular rusty leaf spots, with a yellow halo, are occasionally numerous enough to cause death of foliage, but commonly are only disfiguring. Spray plants in seedbed with bordeaux mixture, or dust with copper lime dust; clean up old refuse.

Pseudomonas syringae pv. **apii**. **Bacterial Leaf Spot** of celery.

Pseudomonas syringae pv. **aptata**. **Bacterial Spot** on beets, Swiss chard, and nasturtium. Spots on nasturtium leaves are water-soaked, brownish, 1/8 to 1/4 inch across. On beets they are dark brown or black, irregular, and in addition there are narrow streaks on petioles, midribs, and larger veins. Petiole tissue may be softened as with soft rot. Infection is only through wounds.

Pseudomonas syringae pv. **coronafaciens**. **Halo Blight** on grasses, such as *Poa* spp. and *Calamagrostis* spp.

Pseudomonas syringae pv. **delphinii**. **Delphinium Black Spot** on delphinium and aconite (monkshood). Irregular tarry black spots on leaves, flower buds, petioles, and stems may coalesce in late stages to form large black areas. The bacteria enter through stomata or water pores. Occasionally this bacterial leaf spot results in some distortion, but most abnormal growth and blackening of buds is due to the cyclamen mite, a much more important problem than black spot.

Control. Remove diseased leaves as noticed; cut and burn all old stalks at end of season; avoid overhead watering. In a wet season spraying with bordeaux mixture may have some value.

Pseudomonas syringae pv. **glycinea**. **Bacterial Blight** of soybean. Perhaps the most common and conspicuous disease of soybean, appearing in fields when plants are half-grown and remaining active until maturity, with defoliation during periods of high humidity or heavy dews. Small, angular, translucent leaf spots, yellow to light brown, turn dark reddish brown to nearly black with age. There is often a white exudate drying to a glistening film on under leaf surfaces. Black lesions appear on stems and petioles, and on pods water-soaked spots enlarge to cover a wide area, darken, and produce an exudate drying to brownish scales; seeds are often infected. Seedlings from infected seed have brown spots on cotyledons and often die. Flambeau and Hawkeye varieties are somewhat less susceptible. Use seed taken from disease-free pods.

Pseudomonas syringae pv. **helianthi**. **Bacterial Leaf Spot** of sunflower. Leaves show brown, necrotic spots, first water-soaked, then dark and oily.

Pseudomonas syringae pv. **hibisci**. **Bacterial Leaf Spot** on *Hibiscus*.

Pseudomonas syringae pv. **lachrymans**. **Angular Leaf Spot** of cucurbits, general on cucumber, muskmelon, summer squash, occasional on other cucurbits. Leaves or stems have irregular, angular, water-soaked spots with bacteria oozing out in tearlike droplets that dry down to a white residue. Eventually the spots turn gray, die, and shrink, leaving holes in foliage. Fruit spots are small, nearly round, with the tissue turning white, sometimes cracking. The bacteria overwinter in diseased plant tissue and in the seed coat. They are spread from soil to stems and later to fruit in rainy weather, also transferred from plant to plant on hands and clothing. Infection is most severe in plants gone over by pickers early in the morning before dew has dried off. *Control*. Plow under or remove vines immediately after harvest.

Pseudomonas syringae pv. **mori**. **Bacterial Blight** of mulberry, general on black and white mulberry. Numerous water-soaked leaf spots join to form brown or black areas with surrounding yellow tissue. Young leaves may be distorted, with dark sunken spots on midribs and veins. Dark stripes with translucent borders on young shoots exude white or yellow ooze from lenticels. Dead twigs and brown leaves resemble fire blight; trees are stunted but seldom killed. Remove and burn blighted branches; do not plant young mulberry trees near infected specimens.

Pseudomonas syringae pv. **mors-prunorum**. **Bacterial Canker** of stone fruits, **Citrus Blast**, **Lilac Blight** on many unreleated plants, including apple, plum, peach, cherry, pear, almond, avocado, citrus fruits, lilacs, flowering stock, rose, beans, cowpeas, oleander, and leaf spot on peas.

On stone fruits all plant parts are subject to attack, but most destructive are elongated water-soaked lesions or gummy cankers on trunks and branches, usually sour-smelling. Dormant buds of cherry and apricot are likely to be blighted, pear blossoms blasted. Small purple spots appear on leaves of plum and apricot, black lesions on fruit of cherry and apricot. All varieties of apricot are very susceptible to the disease. Plums on Myrobalan rootstock are more resistant, and varieties California, Duarte, and President are tolerant.

On citrus, and particularly lemons, dark sunken spots, called black pit, are formed on fruit rind, but there is no decay. The blast form of the disease is most often on oranges and grapefruit – water-soaked areas in leaves, which may drop or hang on, twigs blackened and shriveled. The disease is most serious in seasons with cold, driving rainstorms.

On lilac, brown water-soaked spots on leaves and internodes on young shoots blacken and rapidly enlarge. Young leaves are killed; older leaves have large portions of the blade affected. Infection starts in early spring in rainy weather. The bacteria are primarily in the parenchyma, spreading through intercellular spaces, blackening and killing cells, forming cavities. The vascular system may also be affected, followed by wilting of upper leaves.

Control. Prune out infected twigs and branches. In California spray fruits in fall with bordeaux mixture, at the time first leaves are dropping. Grow bushy, compact citrus trees less liable to wind injury; use windbreaks for orchards.

Pseudomonas syringae pv. **papulans**. **Blister Spot** of apple. Small, dark brown blisters on fruit and rough bark cankers on limbs start at lenticels. Bark may have rough scaly patches from a few inches to a yard long, bordered with a pimpled edge, and with outer bark sloughing off in spring.

Pseudomonas syringae pv. **phaseolicola**. **Bean Halo Blight**, halo spot on common, lima, and scarlet runner beans. The symptoms are those of other bean blights except that there are wide green or yellowish green halos around water-soaked leaf spots, such spots later turning brown and dry. Leaves wilt and turn brown; young pods wither and produce no seed; sometimes plants are dwarfed with top leaves crinkled and mottled. In hot weather, spots are often angular, reddish brown, and without halo. Stem streaks are reddish, with gray ooze; pod spots are red to brown with silver crusts; seeds are small, wrinkled, with cream-colored spots. All snap beans are susceptible; many dry beans – Pinto, Great Northern, Red Mexican, Michelite – are rather resistant.

Control. Use seed from blight-free areas. Blight is rare in California, occasional in Idaho. Plan a 3-year rotation. Do not pick beans when foliage is wet.

Pseudomonas syringae pv. **pisi**. **Bacterial Blight** of pea, general on field and garden peas, especially in East and South, and causing a leaf spot of sweet peas. Dark green water-soaked dots on leaves enlarge and dry to russet brown; stems have dark green to brown streaks. Flowers are killed or young pods shriveled, with seed covered with bacterial slime. Bacteria enter through stomata or wounds, and if they reach the vascular system, either leaflets or whole plants wilt. Vines infected when young usually die. Alaska and Telephone varieties are particularly susceptible.

Control. Avoid wounding vines during cultivation. Sow peas in early spring in well-drained soil. Use disease-free seed and plan a 4-year rotation.

Pseudomonas syringae pv. **porri**. **Bacterial Blight** of shallot.

Pseudomonas syringae pv. **primulae**. **Bacterial Leaf Spot** of primrose in ornamental and commercial plantings in California. Infection is confined to older leaves – irregularly circular brown lesions surrounded by conspicuous yellow halos. Spots may coalesce to kill all or part of leaf. Spraying with bordeaux mixture has prevented infection.

Pseudomonas syringae pv. **savastanoi**. **Olive Knot**, **Bacterial Knot** of olive. Irregular, spongy, more or less hard, knotty galls on roots, trunk, branches, leaf, or fruit pedicels start as small swellings and increase to several inches with irregular fissures. Terminal shoots are dwarfed or killed; whole trees may die. Bacteria enter through wounds, often leaf scars or frost cracks. Variety Manzanilla is most susceptible of the olives commonly grown in California. Another form of this species causes similar galls on ash.

Control. Cut out galls carefully, disinfesting tools; paint larger cuts with bordeaux paste and spray trees with bordeaux mixture in early November, repeating in December and March if infection has been abundant. Do not plant infected nursery trees or bring equipment from an infected orchard into a healthy one.

Pseudomonas syringae pv. **syringae**. **Brown Spot, Foliar** on wild rice (*Zizania*); leaf spot and stem collapse on urd bean; leaf spot and stem canker on Ginkgo.

Oleander Bacterial Gall. Galls or tumors are formed on branches, herbaceous shoots, leaves, and flowers but not on underground parts. Small swellings develop on leaf veins, surrounded by yellow tissue, with bacterial ooze coming from veins in large quantity. Young shoots have longitudinal swellings with small secondary tubercles; young leaves and seedpods may be distorted and curled. On older branches tumors are soft or spongy and roughened with projecting tubercles; they slowly turn dark. Prune out infected portions, sterilizing shears between cuts; propagate only from healthy plants.

Pseudomonas syringae pv. **tabaci** (see *Pseudomonas tabaci*). **Blackfire** of tobacco.

Pseudomonas syringae pv. **tabaci**. **Tobacco Wildfire** on tobacco, tomato, eggplant, soybean, cowpea, pokeberry, and ground-cherry, in all tobacco districts sporadically. Leaf spots have tan to brown dead centers with chlorotic halos. The disease appears first on lower leaves and spreads rapidly in wet weather. The bacteria persist a few months in crop refuse and on seed and enter through stomatal cavities. In buried soybean leaves the bacteria have lived less than 4 months; so fall plowing may be beneficial. Seed stored for 18 months produces plants free from wildfire.

Pseudomonas syringae pv. **tagetis**. **Bacterial Leaf Spot**. Circular necrotic lesions on leaves and petioles. The lesions have dark purple margins. This disease occurs on marigold, sunflower, Jerusalem artichoke, and common ragweed. Apical chlorosis is also caused by this pathogen on sunflower and sunflower seed may be a source of inoculum.

Pseudomonas syringae pv. **tagetis**. **Bacterial Leaf Spot** on compass plant and sunflower.

Pseudomonas syringae pv. **tomato**. **Bacterial Leaf Spot** of crucifers, **Pepper Spot** of cabbage, cauliflower, chinese cabbage, and turnip, mostly in northeastern and Middle Atlantic states. Numerous brown or purple spots range from pinpoint to 1/8 inch in diameter. If spots are very numerous, leaves yellow and drop off. Cauliflower is more commonly affected than cabbage. Bacteria, disseminated on seed or in diseased plant parts, enter through stomata, and visible symptoms appear in 3 to 6 days. Disease is most severe in seedbeds.

Control. Change location of hotbed starting seedlings; use 2-year rotation in field; have seed hot-water treated.

Pseudomonas syringae pv. **tomato**. **Bacterial Speck** of tomato. Numerous, dark brown raised spots on fruit are very small, less than 1/16 inch; they do not extend into flesh and are more disfiguring than harmful.

Pseudomonas syringae pv. **zizaniae**. **Leaf Spot** and **Stem Spot** of wild rice.

Pseudomonas tabaci (see *Pseudomonas syringae* pv. *tabaci*). **Blackfire** of tobacco.

Pseudomonas viburni. **Bacterial Leaf Spot** of viburnum, widespread. Circular water-soaked spots appear on leaves, and irregular sunken brown cankers on young stems, and the bacteria overwinter in leaves, stems or buds. Remove and burn infected leaves. Spray with bordeaux mixture or an antibiotic such as Agrimycin two or three times at weekly intervals.

Pseudomonas viridiflava. **Bacterial Leaf Spot** on basil. **Bacterial Canker** on poinsettia.

Pseudomonas viridilivida. **Louisiana Lettuce Disease** on lettuce, bell pepper, and tomatoes. Numerous water-soaked leaf spots fuse to infect large areas, first with a soft rot, then a dry shriveling. Sometimes outer leaves are rotted and the heart sound. This bacterium also causes greasy canker of poinsettia.

Pseudomonas washingtoniae. This bacterium causes spots on leaves of Washington palm.

Pseudomonas woodsii. **Bacterial Spot** and **Blight** of carnation. Leaf lesions are small, elongated, brown with water-soaked borders, withering to brown sunken areas, with masses of bacteria oozing out of stomata. They are spread in greenhouses by syringing, and outdoors by rain. Follow cultural practices suggested under *P. caryophylli* for carnation wilt.

Pseudomonas sp. **Blueberry Canker** reported from Oregon. Reddish brown to black cankers appear on canes of the previous season; all buds in the cankered areas are killed; stems are sometimes girdled. Varieties Weymouth, June, and Rancocas are resistant, but Jersey, Atlantic, Scammel, Coville, and Evelyn are highly susceptible.

Rhizomonas suberifaciens. **Corky Rot** on lettuce.

Rolstonia solanacearum (formerly *Pseudomonas solanacearum*). **Southern Bacterial Wilt**, also called **Brown Rot**, **Bacterial Ring Disease**, **Slime Disease**, **Granville Wilt** (of tobacco), present in many states but particularly prevalent in the South, from Maryland around the coast to Texas. Southern wilt is common on potatoes in Florida but also appears on many other vegetables – bean, lima bean, castor bean, soybean, velvet bean, beet, carrot, cowpea, peanut, sweetpotato, tomato, eggplant, pepper, and rhubarb. Ornamentals sometimes infected include ageratum, anthurium, dwarf banana, garden balsam, geranium, canna, cosmos, croton, chrysanthemum, dahlia, hollyhock, lead-tree, marigold, nasturtium, Spanish needle, sunflower, and zinnia. The symptoms are those of a vascular disease, with dwarfing or sudden wilting, a brown stain in vascular bundles, and dark patches or streaks in stems. Often the first symptom is a slight wilting of leaves at end of branches in the heat of the day, followed by recovery at night, but each day the wilting is more pronounced and recovery less until the plant dies. Young plants are more susceptible than older ones. In potatoes and tomatoes there may be a brown mushy decay of stems, with bacterial ooze present. Potato tubers often have a browning of vascular ring, followed by general decay.

Bacteria live in fallow soil 6 years or more and may persist indefinitely in the presence of susceptible plants. They are spread by irrigation water, in crop debris, or soil fragments on tools and tractors, or by farm animals. Optimum temperatures are high, ranging from 77° to 97°F, with inhibition of disease below 55°F.

Control. Use northern-grown seed potatoes and Sebago and Katahdin varieties, more resistant than Triumph and Cobbler. Use a long rotation for tomatoes. Soil can be acidified with sulfur to kill bacteria, followed by liming in the fall before planting.

Xanthomonas

Small rods, motile with a single polar flagellum; form abundant slimy yellow growth. Most species are plant pathogens causing necroses.

Ralstonia solanacearum, Race 3, Biovar 2. **Bacterial wilting** of geranium; also yellowing and stunting.
Xanthomonas albilineans. **Leaf Scald** of sugarcane (FL, TX).
Xanthomonas axonopodis. **Leaf Streak** (water soaking) of African lily and **Leaf Blight** of onion.
Xanthomonas begoniae (see *Xanthomonas campestris* pv. *begoniae*). **Begonia Bacteriosis**, leaf spot of fibrous and tuberous begonias.
Xanthomonas campestris. **Black Rot** of cruciers, **Bacterial Blight**, **Wilt**, **Stump Rot** of alder, arabidopsis, asparagus tree fern, avocado, cabbage, cauliflower, broccoli, brussels sprouts, kale, lavender, mustard, radish, rutabaga, sunflower, stock, turnip, and leaf blight of onion. Black rot was first observed in Kentucky and Wisconsin about 1890 and is generally distributed in the country, with losses often 40 to 50% of the total crop. It is one of the most serious crucifer diseases, present each season but epidemic in warm, wet seasons.
The bacteria invade leaves through water pores or wounds and progress to the vascular system. Veins are blackened, with leaf tissue browning in a V-shape. With early infection plants either die or are dwarfed, with a one-sided growth. Late infection results in defoliation, long bare stalks with a tuft of leaves on top. When stems are cut across, they show a black ring, result of the vascular invasion, and sometimes yellow bacterial ooze. Black rot is a hard odorless rot, but it may be followed by soft, odorous decays. Primary infection comes from bacteria carried on seed, or in refuse in soil, but drainage water, rain, farm implements, and animals aid in secondary infection.
Control. Use seed grown in disease-free areas in the West or treat with hot water, 122°F, 25 minutes for cabbage, 18 minutes for broccoli, cauliflower, and collards. Plan a 3-year rotation with plants other than crucifers, and clean up all crop refuse.
Xanthomonas campestris. **Horse-Radish Leaf Spot**. Leaves are spotted but there is no vascular infection. Also causes leaf spot of *Pilea* sp., *Pellionia*

sp. and leaf spot and blight of bird of paradise, white butterfly. Also, bacterial leaf and stem lesions.

Xanthomonas campestris. **Bacterial Leaf Spot** on cabbage and radish.

Xanthomonas campestris pv. **asclepiadis**. **Bacterial Blight** on butterfly weed.

Xanthomonas campestris pv. **barbareae**. **Black Rot** of winter-cress (*Barbarea vulgaris*), similar to black rot of cabbage; small greenish spots turn black.

Xanthomonas campestris pv. **begoniae** (formerly *Xanthomonas begoniae*). **Begonia Bacteriosis**, leaf spot of fibrous and tuberous begonias. Blister-like, roundish dead spots are scattered over surface of leaves. Spots are brown with yellow translucent margins. Leaves fall prematurely, and in severe cases the main stem is invaded, with gradual softening of all tissues and death of plants. Bacteria remain viable at least 3 months in yellow ooze on surface of dried leaves. Leaves are infected through upper surfaces during watering, with rapid spread of disease when plants are crowded together under conditions of high humidity.

Control. Keep top of leaves dry, avoiding syringing or overhead watering; keep pots widely spaced; spray with bordeaux mixture and dip cuttings in it.

Xanthomonas campestris pv. **carotae** (formerly *Xanthomonas carotae*). **Bacterial Blight** of carrot. The chief damage is to flower heads grown for seed, which may be entirely killed. Symptoms include irregular dead spots on leaves, dark brown lines on petioles and stems, blighting of floral parts, which may be one-sided. Use clean seed, or treat with hot water; rotate crops.

Xanthomonas campestris pv. **citri**. **Citrus Canker** on all citrus fruits, but not apparently eradicated from the United States. It came from the Orient and appeared in Texas in 1910, becoming of major importance in Florida and the Gulf States by 1914, ranking with chestnut blight and white pine blister rust as a national calamity. But here is one of the few cases on record where man has won the fight, where a disease has been nearly eradicated by spending enough money and having enough cooperation early in the game. Several million dollars, together with concerted intelligent effort by growers, quarantine measures, destruction of every infected tree, sanitary precautions so rigid they included walking the mules through disinfestant, sterilization of clothes worn by workers – ill saved us from untold later losses.

Symptoms of citrus canker are rough, brown corky eruptions on both sides of leaves and fruit. On foliage the lesions are surrounded by oily or yellow halos. Old lesions become brown and corky.

Xanthomonas campestris pv. **corylina** (formerly *Xanthomonas corylina*). **Filbert Blight**, **Bacteriosis**, the most serious disease of filberts in the Pacific Northwest, known since 1913 from the Cascade Mountains west in Oregon and Washington. The disease is similar to walnut blight (see *X. juglandis*) with infection on buds, leaves, and stems of current growth; on branches; and on trunks 1 to 4 years old. The bacteria are weakly pathogenic to the nuts. Copper-lime dusts are effective, with four to six weekly applications, starting at the early prebloom stage.

Xanthomonas campestris pv. **cucurbitae** (formerly *Xanthomonas cucurbitae*). **Bacterial Spot** on winter squash and pumpkin. Leaf spots are first small and round, then angular between veins, with bright yellow halos; sometimes translucent and thin but not dropping out; often coalescing to involve whole leaf. Bacterial exudate is present.

Xanthomonas campestris pv. **cyamopsidis**. **Rot** of *Lithops* spp.

Xanthomonas campestris pv. **dieffenbachiae**. **Blight** of *Anthurium*; also **Leaf Spot** of cocoyam.

Xanthomonas campestris pv. **dieffenbachiae** (formerly *Xanthomonas dieffenbachiae*). **Dieffenbachia Leaf Spot**. Spots are formed on all parts of leaf blade except midrib, but not on petioles and stems. They range from minute, translucent specks to lesions 3/8 inch in diameter, circular to elongated, yellow to orange-yellow with a dull green center. Spots may grow together to cover large areas, which turn yellow, wilt, and dry. Dead leaves are dull tan to light brown, thin and tough but not brittle. The exudate on lower surface of spots dries to a waxy, silver-white layer.

Control. Separate infected from healthy plants; keep temperature low; avoid syringing; try protective spraying with streptomycin.

Xanthomonas campestris pv. **fragariae**. **Angular Leaf Spot** on strawberry; also **Blossom Blight** on strawberry.

Xanthomonas campestris pv. **glycines** (formerly *Xanthomonas glycines* (*phaseoli* var. *sojense*). **Bacterial Pustule** of soybean, similar to regular bean blight but chiefly a foliage disease, present in most soybean areas, more severe in the South. Small, yellow-green spots with reddish brown centers appear on upper surface of leaves with a small raised pustule at the center of the spot on the under leaf surface. Spots run together to large irregular brown areas, portions of which drop out, giving a ragged appearance.

Bacteria overwinter in diseased leaves and on seed. Variety CNS is highly resistant; Ogden has some resistance.

Xanthomonas campestris pv. **gummisudans** (formerly *Xanthomonas gummisudans*). **Bacterial Blight** of Gladiolus. Narrow, horizontal, water-soaked, dark green spots turn into brown squares or rectangles between veins, covering entire leaf, particularly a young leaf, or middle section of the blade. Bacteria ooze out in slender, twisted, white columns or in a gummy film, in which soil and insects get stuck. Disease is spread by planting infected corms or by bacteria splashed in rain from infected to healthy leaves. The small dark brown corm lesions are almost unnoticeable. Soak corms unhusked for 2 hours before planting.

Xanthomonas campestris pv. **hederae** (formerly *Xanthomonas hederae*). **Bacterial Leaf Spot** of English ivy. Small water-soaked area on leaves develop dark brown to black centers as they increase in size, sometimes cracking, with reddish purple margins. Spots are sometimes formed on petioles and stems, with plants dwarfed and foliage yellow-green. Spray with bordeaux mixture or an antibiotic. Keep plants well spaced; avoid overhead watering and high humidity.

Xanthomonas campestris pv. **hyacinthi** (formerly *Xanthomonas hyacinthi*). **Hyacinth Yellows**, yellow rot of Dutch hyacinth, occasionally entering the country in imported bulbs. The disease was first noted in Holland in 1881 and named for the yellow slime or bacterial ooze seen when a bulb is cut. The bulbs rot either before or after planting, producing no plants above ground or badly infected specimens, which do not flower and have yellow to brown stripes on leaves or flower stalks. Bacteria are transmitted by wind, rain, tools, and clothes, with rapid infection in wet or humid weather, particularly among luxuriantly growing plants. The disease is usually minor in our Pacific Northwest but worse in warm, wet weather on rapidly growing plants. Innocence is more susceptible than King of the Blues.

Control. Cover infected plants with a jar or can until the end of the season; then dig after the others. Never work or walk in fields when plants are wet; avoid bruising; discard rotten bulbs; rotate plantings; avoid fertilizer high in nitrogen.

Xanthomonas campestris pv. **incanae** (formerly *Xanthomonas incanae*). **Bacterial Blight** of garden stocks causing, since 1933, serious losses on flower-seed ranches in California; also present in home gardens. This is a vascular disease of main stem and lateral branches, often extending into leaf petioles and seed peduncles. Seedlings suddenly wilt when 2 to 4 inches high, with stem tissues yellowish, soft and mushy, and sometimes a yellow exudate along stem. On older plants, dark water-soaked areas appear around leaf scars near ground, stem is girdled, and lower leaves turn yellow and drop; or entire plants wilt or are broken by wind at ground level. Bacteria persist in soil and on or in seed;they are also spread in irrigation water.

Control. Use a 2 to 3-year rotation. Treat seed with hot water, 127.5° to 131°F for 10 minutes, followed by rapid cooling.

Xanthomonas campestris pv. **juglandis** (formerly *Xanthomonas juglandis*). **Walnut Blight** on English or Persian walnut, black walnut, butternut, Siebold walnut. Black, dead spots appear on young nuts, green shoots, and leaves. Many nuts fall prematurely, but others reach full size with husk, shell, and kernel more or less blackened and destroyed. Bacteria winter in old nuts or in buds, and may be carried by the walnut erinose mite.

Control. Spray with a fixed copper, as copper oxalate, or with streptomycin. Apply when 10% of the blossoms are open, repeat when 20% are open, and again after bloom.

Xanthomonas campestris pv. **malvacearum**. **Leaf Spot** on *Hibiscus*.

Xanthomonas campestris pv. **oryzae** (formerly *Xanthomonas oryzae*). **Carnation Pimple** reported from Colorado as caused by a new form of the rice blight organism. Very small, 1 mm, pimples are formed near base and tips of leaves, which may shrivel.

Xanthomonas campestris pv. **papavericola** (formerly *Xanthomonas papavericola*). **Bacterial Blight** of poppy on corn poppy and on Oriental, opium, and California poppies. Minute, water-soaked areas darken to intense black spots bounded by a colorless ring. Spots are scattered, circular, small, often zonate, with tissue between yellow and then brown. There is a noticeable, slimy exudate. Infection is through stomata and often into veins. Stem lesions are long, very black, sometimes girdling and causing young plants to fall over. Flower sepals are blackened, petals stop developing; pods show conspicuous black spots.

Control. Remove and destroy infected plants; do not replant poppies in the same location. Try Agrimycin as a preventive spray.

Xanthomonas campestris pv. **pelargonii** (formerly *Xanthomonas pelargonii*). **Bacterial Leaf Spot** of geranium (*Pelargonium*). Irregular to circular brown leaf spots start as water-soaked dots on undersurface, becoming sunken as they enlarge and with tissue collapsing. If spots are numerous, the entire leaf turns yellow, brown, and shriveled, then drops. The leaves sometimes wilt and droop but hang on the plant for a week or so. Exterior of stem is gray and dull, the pith and cortex black, later disintegrating into a dry rot. The roots are blackened but not decayed. Cuttings fail to root, and rot from the base upward. Bacteria can live 3 months in moist soil; are spread by handling, splashing water, cutting knives, and whiteflies.

Control. Remove diseased plants. Take cuttings from plants known to be healthy; place in sterilized media and pots. Commercial growers should purchase culture-indexed cuttings. Be sure to sterilize cutting knives. Use 1-year rotation. Try Agrimycin as a preventive spray, or copper.

Xanthomonas campestris pv. **pelargonii** (formerly *Xanthomonas pelargonii*) **Geranium Leaf Spot** on *Pelargonium* spp. Leaf spots are small, brown, necrotic, sometimes with reddish tinge on upper surface and a slightly water-soaked condition on underside. Young leaves may die and drop. Petioles are occasionally spotted. Bacteria winter in old leaves or under mulch.

Xanthomonas campestris pv. **phaseoli** (formerly *Xanthomonas phaseoli*). **Bacterial Bean Blight**, general and serious on beans but rare in some western states. Leaf spots are at first very small, water-soaked or light green wilted areas, which enlarge, turn brown, are dry and brittle, and have a yellow border around edge of lesions and often a narrow, pale green zone outside that. Leaves become ragged in wind and rainstorms. Reddish brown horizontal streaks appear in stem, which may be girdled and break over at cotyledons or first leaf node.

Pod lesions are first dark green and water-soaked, then dry, sunken and brick red, sometimes with a yellowish encrustation of bacterial ooze. White seeds turn yellow, are wrinkled with a varnished look.

Control. Use disease-free western-grown seed. Keep away from beans when plants are wet.

Xanthomonas campestris pv. **pruni** (formerly *Xanthomonas pruni*). **Bacterial Spot** of stone fruits, also called canker, shot hole, black spot; general on plum, Japanese plum, prune, peach, and nectarine east of the Rocky Mountains; one of the more destructive stone fruit diseases, causing heavy losses in some states.

Symptoms on leaves are numerous, round or angular, small reddish spots with centers turning brown and dead, dropping out to leave shot holes. Spots may run together to give a burned, blighted, or ragged appearance, followed by defoliation, with losses running high in devitalized trees. On twigs dark blisters dry out to sunken cankers. Fruit spots turn into brown to black, saucer-shaped depressions with small masses of gummy, yellow exudate, often with cracking through the spot.

Control. Plant new orchards from nurseries free from the disease. Prune to allow air in the interior of trees. Feed properly; trees with sufficient nitrogen do not defoliate so readily. Zinc sulfate-lime sprays have been somewhat effective.

Xanthomonas campestris pv. **raphani** (formerly *Xanthomonas vesicatoria* var. *raphani*). **Leaf Spot** of radish, turnip, and other crucifers, similar to bacterial spot on tomato.

Xanthomonas campestris pv. **vesicatoria** (formerly *Xanthomonas vesicatoria*). **Bacterial Spot** of tomato and pepper, common in wet seasons. Small, black, scabby fruit spots, sometimes with a translucent border, provide entrance points for secondary decay organisms. Small, dark greasy spots appear on leaflets and elongated black spots on stems and petioles. Bacteria are carried on seed.

Control. Rotate crops; destroy diseased vines. Spraying or dusting with copper may reduce infection. These may be combined with streptomycin.

Xanthomonas campestris pv. **vignicola** (formerly *Xanthomonas vignicola*). **Cowpea Canker** on cowpeas and red kidney beans, a destructive disease, first described in 1944. Beans are blighted; cowpea stems have swollen, cankerlike lesions,with the cortex cracked open and a white bacterial exudate. The plants tend to break over. Leaves, stems, pods, and seeds are liable to infection. Chinese Red cowpeas seem particularly susceptible, but the disease appears on other varieties.

Xanthomonas campestris pv. **vitians** (formerly *Xanthomonas vitians*). **Bacterial Wilt** and **Leaf Spot** of lettuce, **South Carolina Lettuce Disease**, wilting and rotting of lettuce leaves and stems. In early stages plants are lighter green than normal. Leaves may have definite brown spots coalescing to large areas or may wilt following stem infection. Use windbreaks to prevent injuries affording entrance to bacteria; also causes leaf spot of pepper and tomato.

Xanthomonas campestris pv. **zinniae**. **Leaf and Flower Spot** of zinnia.

Xanthomonas campestris pv. **zinniae** (formerly *Xanthomonas nigromaculans*). **Leaf Spot** on zinnia.

Xanthomonas carotae (see *Xanthomonas campestris* pv. *carotae*). **Bacterial Blight** of carrot.

Xanthomonas corylina (see *Xanthomonas campestris* pv. *corylina*). **Filbert Blight**, **Bacteriosis**, the most serious disease of filberts in the Pacific Northwest, known since 1913 from the Cascade Mountains west in Oregon and Washington.

Xanthomonas cucurbitae (see *Xanthomonas campestriis* pv. *cucurbitae*). **Bacterial Spot** on winter squash and pumpkin

Xanthomonas dieffenbachiae (see *Xanthomonas campestriis* pv. *dieffenbachiae*). **Dieffenbachia Leaf Spot**. Spots are formed on all parts of leaf blade except midrib, but not on petioles and stems.

Xanthomonas glycines (*phaseoli* var. *sojense*) (see *Xanthomonas campestris* pv. *glycines*). **Bacterial Pustule** of soybean, similar to regular bean blight but chiefly a foliage disease, present in most soybean areas, more severe in the South

Xanthomonas gummisudans (see *Xanthomonas campestris* pv. *gummisudans*). **Bacterial Blight** of Gladiolus.

Xanthomonas hederae (see *Xanthomonas campestris* pv. *hederae*). **Bacterial Leaf Spot** of English ivy.

Xanthomonas hyacinthi (see *Xanthomonas campestris* pv. *hyacinthi*). **Hyacinth Yellows**, yellow rot of Dutch hyacinth, occasionally entering the country in imported bulbs.

Xanthomonas incanae (see *Xanthomonas campestris* pv. *incanae*). **Bacterial Blight** of garden stocks causing, since 1933, serious losses on flower-seed ranches in California; also present in home gardens.

Xanthomonas juglandis (see *Xanthomonas campestris* pv. *juglandis*). **Walnut Blight** on English or Persian walnut, black walnut, butternut, Siebold walnut.

Xanthomonas oryzae (see *Xanthomonas campestris* pv. *oryzae*). **Carnation Pimple** reported from Colorado as caused by a new form of the rice blight organism. **Xanthomonas papavericola** (see *Xanthomonas campestris* pv. *papavericola*). **Bacterial Blight** of poppy on corn poppy and on Oriental, opium, and California poppies.

Xanthomonas pelargonii (see *Xanthomonas campestris* pv. *pelargonii*). **Bacterial Leaf Spot** of geranium (*Pelargonium*).

Xanthomonas pelargonii (see *Xanthomonas campestris* pv. *pelargonii*). **Geranium Leaf Spot** on *Pelargonium* spp.

Xanthomonas phaseoli (see *Xanthomonas campestris* pv. *phaseoli*). **Bacterial Bean Blight**, general and serious on beans but rare in some western states.

Xanthomonas pruni (see *Xanthomonas campestris* pv. *pruni*. **Bacterial Spot** of stone fruit, also called canker, shot hole, black spot; general on plum, Japanese plum prune, peach, and nectarine east of the Rocky Mountains.

Xanthomonas vesicatoria (see *Xanthomonas campestris* pv. *vesicatoria*. **Bacterial Spot** of tomato and pepper, common in wet seasons.

Xanthomonas vesicatoria var. **raphani** (see *Xanthomonas campestris* pv. *raphani*). **Leaf Spot** of radish, turnip, and other crucifers, similar to bacterial spot on tomato.

Xanthomonas vignicola (see *Xanthomonas campestris* pv. *vignicola*). **Cowpea Canker** on cowpeas and red kidney beans.

Xanthomonas vitians (see *Xanthomonas campestris* pv. *vitians*). **Bacterial Wilt** and **Leaf Spot** of lettuce, **South Carolina Lettuce Disease**, wilting and rotting of lettuce leaves and stems.

Xanthomonas nigromaculans (see *Xanthomonas campestris* pv. *zinniae*). **Leaf Spot** on zinnia.

Xylella fastidiosa. **Bacterial Leaf Scorch** on maple, pecan, mulberry, northern red oak and sweet gum.

Pierce's Grape Disease. First described as California vine disease by Pierce in 1892, now known as cause of grape degeneration in Gulf states; reported from Rhode Island. First symptoms are scalding and browning of leaf tissues, often with veins remaining green; canes die back from tips in late summer; growth is dwarfed, fruit shriveled; roots die. The bacterium invades the xylem and turns it brown. Alfalfa plants are stunted with short stems and small leaves. Many species of sharpshooter leafhoppers transmit the bacterium to grape from alfalfa, clovers, grasses, also from ivy, acacia, fuchsia, rosemary, zinnia, and other ornamentals that are symptomless carriers. There is no adequate control; roguing of diseased vines and spraying for leafhoppers has proved ineffective. Propagate by cuttings from disease-free vineyards.

Mycoplasmataceae

Phytoplasma

Ash Yellows and **Witches' Broom**. On ash in Michigan, Montana, Nebraska, North Carolina, and South Dakota and peanut in Oklahoma.

Aster Yellows. Throughout the United States, also called Lettuce Rio Grande Disease, Lettuce White Heart, Potato Purple Top.

Bean Phyllody. Perhaps caused by a strain of aster-yellows MLO.

California Aster Yellows. In the West, also known as Celery Yellows, Western.

Aster Yellows, Potato Late Break, Strawberry Green Petal. Aster yellows may appear in more than 170 species of 38 families of dicotyledons. It is serious on China aster, may also affect anemone, calendula, coreopsis, cosmos, purple coneflower (Echinacea), delphinium, daisies, golden-glow, hydrangea, marigold, petunia, phlox, scabiosa, strawflower, and other flowers. It is serious on lettuce, alfalfa, endive, carrot, parsley, New Zealand spinach, radish, and some other vegetables, but not on peas, beans, or other legumes. This disease is now known to be caused by a phytoplasma organism.

In most plants vein clearing is followed by chlorosis of newly formed tissues, adventitious growth, erect habit, virescence of flowers. Asters have a stiff yellow growth with many secondary shoots; are stunted, with short internodes; flowers are greenish, dwarfed, or none. The chief vector is the six-spotted leafhopper (*Macrosteles fascifrons*). The virus multiplies in the insect, and there is a delay of 10 days or more after the insect feeds on a diseased plant before it can infect a healthy specimen. There is no transmission through insect eggs or aster seeds.

Celery petioles are upright, somewhat elongated, with inner petioles short, chlorotic, twisted, brittle, often cracked, yellow. The celery strain of the virus causes yellowing and stunting of cucumber, squash, pumpkin; infects gladiolus and zinnia.

Control of aster yellows is directed against the leafhoppers. Asters are grown commercially under frames of cheesecloth, 22 threads to the inch, or wire screening, 18 threads to the inch. In home gardens all diseased plants should be rogued immediately and overwintering weeds, which harbor leafhopper eggs, destroyed. Spraying or dusting ornamentals and vegetables with pyrethrum will reduce the number of vectors but will not entirely eliminate the disease.

Recent work raises the probability that the etiological agent of aster yellows is a mycoplasma rather than a virus. Therefore, treatment with antibiotics, such as chlortetracycline, has suppressed the development of yellows symptoms. Mycoplasma-like bodies have been seen in microscopic study of diseased plants and in transmitting leafhopper vectors, but not in healthy plants or nontransmitting vectors.

Clover Proliferation. On strawberry and onion.

Corn Stunt. A dwarfing disease present primarily in the South; transmitted by leafhoppers. Mycoplasma-like bodies present; See *Spiroplasma citri*.

Elm Phloem Necrosis. On American elm from West Virginia and Georgia to northern Mississippi, eastern Oklahoma, Kansas, and Nebraska. Origin unknown but apparently present since 1882; the disease reached epidemic proportions in Ohio in 1944, killing 20,000 trees that year near Dayton and 10,000 at Columbus. The most reliable diagnostic character is a buttercup yellow discoloration of the phloem, often flecked with brown or black and an odor of wintergreen. Destruction of phloem causes the bark to loosen and fall away. Roots die first, then the phloem in lower portions of tree, followed by wilting and defoliation. American elms may be attacked at any age; they wilt and die suddenly within 3 or 4 weeks or gradually decline for 12 to 18 months. This is now thought to be caused by a mycoplasma-like agent.

Transmission is by the white-banded elm leafhopper (*Scaphoideus luteolus*) and possibly other species. Nymphs hatch about May 1 from eggs wintered on elm bark and feed on leaf veins. Adults move from diseased to healthy trees.

There is hope of propagating elms resistant to phloem necrosis. Communities should interplant existing elms with Asiatic or European varieties or with some other type of tree to provide shade if and when present elms die.

Peach Western X-Disease. Perhaps same as X-disease but usually treated separately; also known as cherry buckskin and western-X little cherry. The pathogen is transmitted by leafhoppers (*Colladonus germinatus, Fieberella florii, Osbornellus borealis*, and others) to peach, nectarine and cherry in western states. Symptoms vary according to rootstock, but cherry fruit is smaller than normal. Sour cherries are puttylike, pinkish; sweet cherries are small, conical, hang on trees late, fail to develop normal color. Symptoms on peach are similar to those of X-disease.

Peach X-Disease. On peach and chokecherry, sometimes cherry in the northern United States and of major importance in Connecticut, Massachusetts, and New York. Peach trees appear normal in spring for 6 or 7 weeks after growth starts, then foliage shows a diffused yellow and red discoloration with a longitudinal upward curling of leaf edges; spots may drop out, leaving a tattered effect. Defoliation starts by mid-summer. Fruits shrivel and drop or ripen prematurely. Seed do not develop. Weakened trees are killed by low temperatures or remain unproductive.

Chokecherry has conspicuous premature reddening of foliage, dead embryos in fruit. The second and third seasons after infection foliage colors are duller, there are rosettes of small leaves on terminals, and death may follow. Natural infection is apparently from chokecherry to peach (not peach to peach or peach to chokecherry) by a leafhopper (*Colladonus clitellarius*). Elimination of chokecherries within 500 feet of peach trees provides the best control.

Peach Yellow Leaf Roll; a form of Western X-Disease; perhaps caused by a more severe strain of the MLO.

Peach Yellows; Little Peach. First noted near Philadelphia in 1791 and so serious that in 1796 the American Philosophical Society offered a $60 prize for the best method of preventing premature decay of peach trees. Present in eastern states on peach, almond, nectarine, apricot and plum. Not found west of the Mississippi or in the South. In peach, clearing of veins, production of thin erect shoots with small chlorotic leaves, premature ripening of fruit (with reddish streaks in flesh and insipid taste) is followed by death of the tree in a year or so. The little peach strain of the MLO causes distortion of young leaves at tips of branches, small fruit, delayed ripening. Plum is systemically infected, with few obvious symptoms. Transmission is by the plum leafhopper or budding.

Control. Budsticks and dormant nursery trees can be safely treated with heat sufficient to kill the MLO (122°F for 5 to 10 minutes), but cured trees are susceptible to reinfection. Most effective control is removal of wild plum trees around peach orchard and spraying to control leafhoppers.

Potato Apical Leaf Roll and **Arizona Purple Top Wilt**. Caused by aster yellows.

Strawberry Green Petal. Perhaps due to a strain of aster yellows MLO, as is chlorotic phyllody reported from Louisiana. Flowers have enlarged sepals, small green petals.

Bud Proliferation and **Delayed Maturity**, on soybean.

Decline of ash.

Lethal Yellowing on palms.

Phloem Necrosis of chrysanthemum.

Spiroplasma citri. **Corn Stunt**. Has been reported on corn, onions, horseradish, shepherd's purse, yellow rocket, and wild mustard.

Stunt of blueberry.

Virescence on horseradish.

Witches' Broom on pigeon pea (*Cajanus cajan*), and black raspberry.

Witches' Broom on Japanese persimmon, and lilac.

Witches' Broom and **Yellowing** on annual statice.

Yellows of elm.

BLACK KNOT

The term black knot is used to designate a disease with black knotty excrescences.

Apiosporina

Ascomycetes, Pleosporales

Asci are in locules, without well-marked perithecial walls, immersed in a massive, carbonaceous stroma, erumpent and superficial at maturity. Spores are hyaline, unequally two-celled.

Apiosporina morbosa (formerly *Dibotryon morbosum*). **Black Knot** of plum and cherry, **Prunus Black Knot**, **Plum Wart**, widespread and serious on garden plums, also present on sweet and sour cherries, chokecherry, and apricot. Apparently a native disease, destructive in Massachusetts by 1811 and the pathogen described from Pennsylvania in 1821, black knot has been reported on peach, long thought to be immune.

The chief symptoms are black, rough, cylindrical or spindle-shaped enlargements of twigs into knots two to four times their thickness and several inches long (see Fig. 3.6). Infection takes place in spring, but swelling is not evident until growth starts the following spring, at which time the bark ruptures, and a light yellowish growth fills the crevices. In late spring this is covered with an olive green, velvety layer made up of brownish conidiophores and one-celled hyaline conidia of the anamorph *Hormodendron* state. Conidia are spread by wind.

In late summer black stromata cover the affected tissues, and the galls become hard. Asci are formed during the winter in cavities in the stroma; ascospores are discharged and germinate in early spring, completing the 2-year cycle. Knots are produced from primary infection by ascospores or from secondary infection from mycelium formed in old knots and growing out to invade new tissue. Limbs may be girdled and killed; trees are stunted

Figure 3.6 Black Knot on *Prunus* sp

and dwarfed, nearly worthless after a few years. Old knots may be riddled with insects or covered with a pink fungus growing on the *Apiosporina* mycelium.

Control. Cut out infected twigs and branches, 3 or 4 inches beyond the knot, to include advancing perennial mycelium. Do this in winter or before April 1. Eradicate or thoroughly clean up wild plums and cherries in the vicinity. Spray at delayed dormant stage in spring (just as buds break) with bordeaux mixture or with liquid lime sulfur. The latter is preferable unless oil is combined in the spray as an insecticide. Spray with lime sulfur at full bloom.

Dibotryon morbosum (see *Apiosporina morbosa*). **Black Knot** of plum and cherry, **Prunus Black Knot**, **Plum Wart**, widespread and serious on garden plums, also present on sweet and sour cherries, chokecherry, and apricot.

Leptosphaeria

Ascomycetes, Dothideales

Perithecia in clusters on wood; spores dark, with several cells.

Gibberidea heliopsidis (see *Leptosphaeria heliopsidis*). **Black Knot**, **Black Patch** on goldenrod and sunflower.

Leptosphaeria heliopsidis (formerly *Gibberidea heliopsidis*). **Black Knot**, **Black Patch** on goldenrod and sunflower.

BLACKLEG

The term blackleg is used to describe darkening at the base of a stem or plant. Blackleg of potatoes and delphinium are described under Bacterial Diseases; blackleg of geraniums is under Rots.

Cylindrocarpon

► Rots.

Cylindrocarpon obtusisporum. Blackleg; on grape.

Phoma

Deuteromycetes, Coelomycetes

Pycnidia dark, ostiolate, lenticular to globose, immersed in host tissue, erumpent or with short beak piercing the epidermis; conidiophores short or obsolete, conidia small, one-celled, hyaline, ovate to elongate; parasitic on seed plants, chiefly on stems and fruits, rarely on leaves.

Phoma lingam. **Blackleg** of crucifers, **Foot Rot**, **Phoma Wilt** of plants of the mustard family, including cabbage, cauliflower, Chinese cabbage, brussels sprouts, charlock, garden cress, pepper grass, kale, kohlrabi, mustard, rape, radish, rutabaga, turnip, stock, and sweet alyssum. The teleomorph state, *Lystosphaeria maculans* has been found on cabbage.The fungus was first noticed in Germany in 1791; the disease was reported in France in 1849, and in the United States in 1910. It is generally distributed east of the Rocky Mountains and formerly caused from 50 to 90% loss. With improved seed and seed treatment it has become less important.
The first symptom is a sunken area in the stem near the ground, which extends until the stem is girdled and the area turns black. Leaves, seed stalks, and seed pods have circular, light brown spots. Small black pycnidia appear-

ing on the lesions distinguish blackleg from other cabbage diseases. The leaves sometimes turn purple and wilt, but there is no defoliation, as in black rot.

The fungus reaches the soil via infected plant debris, remaining alive 2 or more years. Spores are spread by splashing rain, or manure, on tools, and perhaps by insects, with new lesions resulting in 10 to 14 days. But the chief spread is by mycelium wintering in infected seed. When such seed is planted, fruiting bodies are formed on cotyledons as they are pushed above ground, and these serve as a source of inoculum for nearby plants. A few diseased seed can start an epiphytotic in wet weather.

Control. Use seed grown on the Pacific Coast, which is usually, although not always, disease-free. If the seed is infected, tie loosely in cheesecloth bags and immerse in hot water, held at 122°F for 30 minutes. It is sometimes possible to buy seed already treated. Sterilize soil for the seedbed; use a 3-year rotation; do not splash seedlings when watering; do not transplant any seedlings if the disease shows up in the seedbed; do not feed cabbage refuse to cattle; do not transfer cultivators and other tools from a diseased to a healthy field without using a disinfestant.

Leptosphaeria

Leptosphaeria maculans. **Blackleg** on canola.

BLACK MILDEW

The terms black mildew, sooty mold, and black spot have been used to some extent interchangeably. In this text the term sooty mold is restricted to those fungi living on insect exudate and hence not true parasites. Included here under Black Mildew are parasitic fungi that have a superficial dark mycelium. They are members of the Erysiphales (Meliolales according to some classifications) and hence similar to powdery mildews except for the dark color, or they belong to the Hemisphaeriales, characterized by a dark stroma simulating the upper portion of a perithecium. In a few cases the diseases are called black spot rather than mildew.

Apiosporina

Ascomycetes, Pleosporales

Perithecia and mycelium superficial; mycelium with setae and perithecia usually hairy; paraphysoids present; spores two-celled; dark.

Apiosporina collinsii. **Witches' Broom** of serviceberry (*Amelanchier*) widespread. Perennial mycelium stimulates the development of numerous stout branches into a broom. A sooty growth on underside of leaves is first olive brown, then black. Numerous globose, beadlike, black perithecia appear in late summer. The damage to the host is not serious.

Asterina

Ascomycetes, Asterinales

Asterina species are parasites on the surface of leaves and are usually found in warm climates. In some cases the disease is called black mildew, in others, black spot. The perithecia are dimidiate, having the top half covered with a shield, a small, round stroma composed of radially arranged dark hyphae. Underneath this stromatic cover, called scutellum, there is a single layer of fruiting cells; paraphyses are lacking; spores are dark, two-celled. The mycelium, which is free over the surface, has lobed appendages, hyphopodia, which act as haustoria in penetrating the cuticle and obtaining nourishment from the host.

Asteridium lepidigenum (formerly *Asterina lepidigena*). **Black Mildew** on lyonia, Florida.
Asterina anomala (see *Limacinula anomala*). **Black Mildew** on California-laurel, California.
Asterina delitescens. **Black Spot** on redbay.
Asterina diplopoides. **Black Spot** on leucothoë.
Asterina gaultheriae (see *Schizothyrium pomi*). **Black Mildew** on bearberry, Wisconsin.
Asterina lepidigena (see *Asteridium lepidigenum*). **Black Mildew** on lyonia, Florida.
Asterina orbicularis. **Black Spot** on American holly and *Ilex* spp.
Limacinula anomala (formerly *Asterina anomala*). **Black Mildew** on California-laurel, California.
Schizothyrium pomi (formerly *Asterina gaultheriae*). **Black Mildew** on bearberry, Wisconsin.

Asterinella

Ascomycetes, Asterinales

Like *Asterina* but lacking hyphopodia; with or without paraphyses; spores dark, two-celled.

Asterinella puiggarii. **Black Spot** on eugenia.

Dimerosporium

According to some authorities this is the same as *Asterina* but the name *Dimerosporium* is in common use.
Dimerosporium abietis (see *Rasutoria abietiis*). **Black Mildew** on Pacific silver and lowland white firs.
Dimerosporium hispidulum. **Black Mildew** on boxelder.
Dimerosporium pulchrum. **Black Mildew** on ash.
Dimerosporium robiniae. **Black Mildew** on ailanthus.
Dimerosporium tropicale. **Black Mildew** on bignonia, Mississippi.

Rasutoria abietiis (formerly *Dimerosporium abietis*). **Black Mildew** on Pacific silver and lowland white firs. Black patches are formed on older needles, usually on under surface. There is no apparent injury to trees.

(Irene) Asteridiella

Ascomycetes, Meliolales

Mycelium with capitate hyphopodia but no bristles; perithecia with larviform appendages; spores dark, with several cells.

Appendiculella araliae (formerly *Irene araliae*). **Black Mildew** on magnolia, Mississippi.
Appendiculella calostroma (formerly *Irene calostroma*). **Black Mildew** on wax-myrtle, Gulf States.
Appendiculella perseae (formerly *Irene perseae*). **Black Mildew** on avocado, Florida.
Like *Irene* except that perithecia have no appendages.
Asteridiella manca (formerly *Irenina manca*). **Black Mildew** on wax-myrtle, Mississippi.
Irene araliae (see *Appendiculella araliae*). **Black Mildew** on magnolia, Mississippi.
Irene calostroma (see *Appendiculella calostroma*). **Black Mildew** on wax-myrtle, Gulf States.
Irene perseae (see *Appendiculella perseae*). **Black Mildew** on avocado, Florida.
Irenina manca (see *Asteridiella manca*). **Black Mildew** on wax-myrtle, Mississippi.

Lembosia (Morenoella)

Ascomycetes, Dothideales

Brown vegetative mycelium with hyphopodia on surface of host; linear stroma, scutellum, over single layer of fruiting cells; paraphyses present; spores dark, two-celled.

Echidnodella angustiformis (formerly *Morenoella angustiformis*). **Black Mildew** on holly (*Ilex* spp.), Mississippi.
Echidnodella rugispora (formerly *Lembosia rugispora*). **Black Mildew** on redbay, swampbay, Mississippi, North Carolina.

Lembosia cactorum. **Black Mildew** on cactus, Florida.
Lembosia coccolobae. **Black Mildew** on sea-grape, Florida; also *L. portoricensis* and *L. tenella*.
Lembosia illiciicola. **Black Mildew** on anise-trees, Alabama, Mississippi.
Lembosia rugispora (see *Echidnodella rugispora*). **Black Mildew** on redbay, swampbay, Mississippi, North Carolina.
Morenoella angustiformis (see *Echidrodella angustiformis*). **Black Mildew** on holly (*Ilex* spp.), Mississippi.
Schiffnerula pulchra. On dogwood.

Meliola

Ascomycetes, Erysiphales (or Meliolales), Meliolaceae

Most abundant in tropics. Superficial dark mycelium with hyphopodia and setae; perithecia globose, coal black without ostiole or appendages but often with setae; spores several-celled, dark; paraphyses lacking. Conidia are lacking in most species, of *Helminthosporium* type in others.

Diplotheca tunae (formerly *Meliola wrightii*). **Black Mildew** on chinaberry.
Irenopsis cryptocarpa (formerly *Meliola cryptocarpa*). **Black Mildew** on gordonia.
Irenopsis martiniana (see *Meliola martiana*). **Black Mildew** on redbay, swampbay, Alabama, Florida, Mississippi.
Meliola amphitricha. **Black Mildew** on boxelder, magnolia, redbay, swampbay.
Meliola bidentata. **Black Mildew** on bignonia.
Meliola camelliae. **Black Mildew** of camellia. Abundant black growth may cover camellia leaves and twigs. Spraying with a light summer oil is sometimes effective.
Meliola cookeana. **Black Mildew** on callicarpa, lantana.
Meliola cryptocarpa (see *Irenopsis cryptocarpa*). **Black Mildew** on gordonia.
Meliola lippiae. **Black Mildew** on lippia.
Meliola magnoliae. **Black Mildew** on magnolia.
Like *Irene* except that mycelium has setae (stiff bristles) and perithecia lack larviform appendages.

Meliola martiana (formerly *Irenopsis martiniana*). **Black Mildew** on redbay, swampbay, Alabama, Florida, Mississippi.
Meliola nidulans. **Black Mildew** on blueberry, wintergreen.
Meliola palmicola. **Black Mildew** on palmetto.
Meliola tenuis. **Black Mildew** on bamboo.
Meliola wrightii (see *Diplotheca tunaei*). **Black Mildew** on chinaberry.

Sthughesia

Ascomycetes, Dothideales

Perithecia smooth; spores two-celled, dark; paraphyses lacking.

Dimerium juniperi (see *Sthughesia juniperi*). **Black Mildew** on Rocky Mountain juniper, California.
Sthughesia juniperi (formerly *Dimerium juniperi*). **Black Mildew** on Rocky Mountain juniper, California.

BLACKSPOT

In common usage the term black spot without qualifying adjectives has come to mean but one disease, rose black spot, with the two words currently written as one, blackspot. This section is limited to the rose disease. Delphinium black spot will be found under Bacterial Diseases, elm black spot under Leaf Spots, other black spots under Black Mildew.

Diplocarpon

Ascomycetes, Helotiales, Dermateaceae (Mollisiaceae)

Apothecia innate, formed in dead leaves, but at maturity rupturing overlying tissues; horny to leathery with a thick margin or outer wall (excipulum) of dark, thick-walled cells; spores two-celled, hyaline; paraphyses present. Anamorph state is a *Marssonina* with two-celled hyaline spores in an acervulus.

Diplocarpon rosae. **Rose Blackspot**, general on rose but less serious in the semi-arid Southwest; reported from all states except Arizona, Nevada, and Wyoming.

For nearly 100 years the fungus was known only by its anamorph state, which has had about 25 different names. The first definite record is by Fries in Sweden in 1815, under the name *Erysiphe radiosum*, but the first valid description was by Libert in 1827 as *Asteroma rosae*. Later Fries called it *Actinonema rosae*, and that term was widely used until *Actinonema* species were transferred to *Marssonina*. The blackspot fungus was first reported in the United States in 1831, from Philadelphia, and in 1912 Wolf made the connection with the teleomorph state, so that the correct name became *Diplocarpon rosae*.

Blackspot is probably the most widely distributed and best known rose disease. It is confined to roses, garden and greenhouse, and may affect practically all varieties, although not all are equally susceptible. There has been some progress made in breeding resistant varieties, but recent investigation

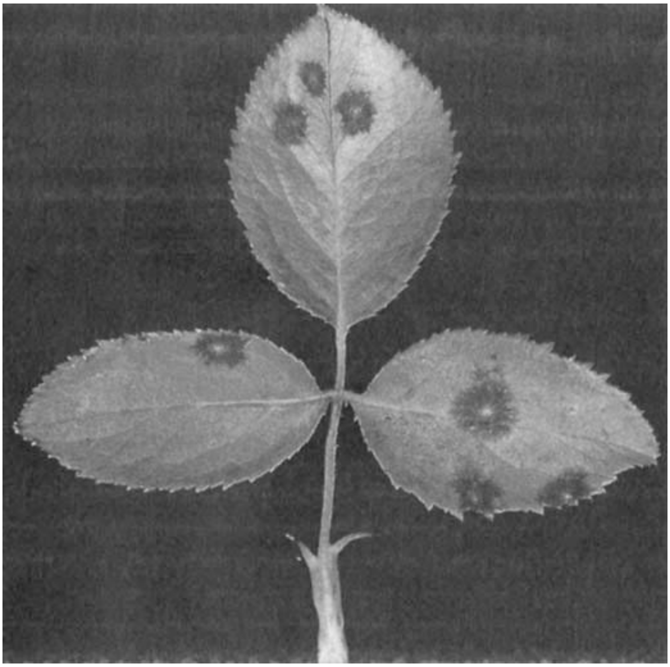


Figure 3.7 Rose Blackspot. Note fimbriate margin to spot

disclosing many physiological races of the fungus explains why roses that are almost immune to blackspot in one location may succumb in another. *Rosa bracteata* is the only species thus far shown to be reasonably resistant to all the different races tested. Roses with the Pernetiana parentage, which has given us the lovely yellows, coppers, and blends, are especially prone to blackspot. Some roses, like Radiance, are tolerant of blackspot, usually holding their leaves, even though they cannot be considered resistant.

Symptoms are primarily more or less circular black spots, up to 1/2 inch in diameter, with radiating fimbriate or fringed margins (see Fig. 3.7). This fimbriate margin is a special diagnostic character, differentiating blackspot from other leaf spots and from discolorations due to cold or chemicals. The spots vary from one or two to a dozen or more on a leaf, usually on the upper surface. With close examination you can see small black dots or pimples in the center of the spots. These are the acervuli, bearing conidia, and they glisten when wet (see Fig. 3.8).

In susceptible varieties the appearance of black spots is soon followed by yellowing of a portion or all of leaflets and then by defoliation. The leaf

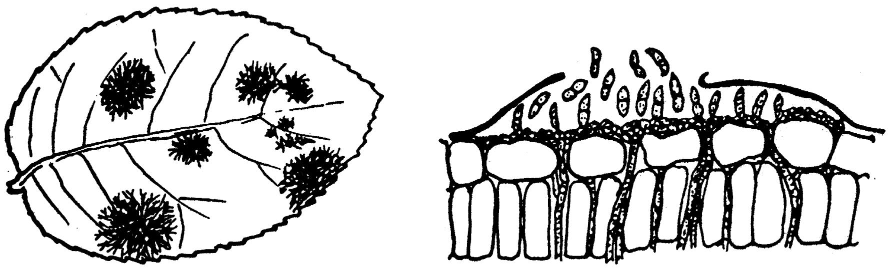


Figure 3.8 Rose Blackspot. Two-celled conidia formed in Acervulus under cuticle

fall is apparently correlated with increased production of ethylene gas in diseased tissue and perhaps by a difference in auxin gradient between leaf and stem. Some roses lose almost all their leaves, put out another set and lose those, and often are trying to leaf out for the third time by late summer. The process is so devitalizing that some bushes may die during the following winter. On tolerant varieties leaf spots are present, though usually in smaller numbers, but there is much less yellowing and defoliation. Cane lesions are small indistinct black areas, slightly blistered, without fimbriate margins.

Infection occurs through either leaf surface, the fungus sending its germ tube directly through the cuticle by mechanical pressure. The hyphae form a network under the cuticle, joining together into several parallel filaments radiating from the point of infection. The hyphae are actually colorless, the black color of the spot coming from the death and disorganization of host cells. The mycelial growth is between cells, with haustoria (suckers) invading epidermal and palisade cells for nourishment.

Acervuli, summer fruiting bodies, formed just under the cuticle, bear two-celled hyaline conidia on short conidiophores on a thin, basal stroma. Splashed by rain or overhead watering, or spread by gardeners working among wet plants, the conidia germinate and enter a leaf if there is continued moisture for at least 6 hours. Rain, heavy dew, fog, and sprinklers used late in the day so foliage does not dry off before night provide the requisite moisture. New spots show up within a week and new spores within 10 days. Secondary cycles are repeated all summer – from late May to late October around New York City.

In my personal experience, the spread of disease is most rapid where large numbers of susceptible varieties are massed together. If all the yellows, for instance, are planted together, the disease gets such a head start, and builds up so much inoculum to spread to the more tolerant red and pink varieties nearby, that these varieties also are more heavily infected than usual. When roses are mixed in beds so that one or two particularly susceptible bushes are surrounded by more resistant types, the infective material cannot increase so rapidly, and the net result is less disease in the garden as a whole. Protected corners in the garden where air circulation is poor also increase the disease potentiality. Spores are apt to be splashed farther when water hits hard-packed soil without a mulch.

When old leaves drop to the ground, the mycelium continues a saprophytic existence, growing through dead tissue with hyphae that are now dark in color. In spring three types of fruiting bodies may be formed: microacervuli or spermagonia containing very small cells that perhaps act as male cells; apothecia, the sexual fruiting bodies formed on a stroma between the epidermis and palisade cells and covered with a circular shield of radiating strands; and winter acervuli, formed internally and producing new conidia in spring. The *Diplocarpon* or apothecial stage is apparently not essential; it is known only in northeastern United States and south-central Canada. The shield over the apothecium ruptures, and the two-celled ascospores are forcibly discharged into the air to infect lowest leaves.

Where the sexual stage is not formed, primary spring infection comes from conidia splashed by rain to foliage overhead, from acervuli either in overwintered leaves on the ground or in cane lesions. New roses from a nursery sometimes bring blackspot via these cane lesions to a garden previously free of disease.

Control. The importance of sanitation may have been somewhat overstressed; it cannot replace routine spraying or dusting. It is certainly a good idea to pick off for burning the first spotted leaves, if this is done when bushes are dry so that the act of removal does not further spread the fungus. Raking up old leaves from the ground at the end of the season makes the garden neater and may reduce the amount of inoculum in spring, but, because the fungus winters also on canes in most sections of the country, removal of leaves cannot be expected to provide a disease-free garden the next season. Comparative tests have shown that fall cleanup is ineffectual. A good mulch, applied after uncovering and the first feeding in spring, serves as a mechanical barrier between inoculum from overwintered leaves on the ground and developing leaves overhead. A mulch also reduces disease by reducing the distance spores can be splashed from one bush to another during the season. Drastic spring pruning, far lower than normal, reduces the amount of inoculum from infected canes.

The importance of a dormant spray is debatable. Experiments have shown that as a true eradicant, applied in winter, it has little value in reducing the amount of blackspot the next summer. Use liquid lime sulfur after pruning, provided the buds have not broken far enough to show the leaflets.

Summer spraying or dusting, weekly throughout the season (from late April to early November in New Jersey) is essential if you want to keep enough foliage on bushes for continuous production of fine flowers (it takes food manufactured in several leaves to produce one bloom) and for winter survival. Some strong varieties will, however, live for years without chemical treatment; they are usually scraggly bushes with erratic bloom. The idea that floribunda varieties do not require as much spraying as hybrid teas is a misconception. Some floribundas are quite resistant; others are very susceptible. The same holds true for old-fashioned shrub roses. All too often blackspot gets a head start in a garden from shrub roses we thought it unnecessary to spray.

Roses can be defoliated as readily by chemicals as by the blackspot fungus; so the fungicide chosen must be safe under the conditions of applications as well as effective. There are many chemicals that will control blackspot if they are applied regularly and thoroughly. Choice depends somewhat on climate. Some copper sprays and dusts cause red spotting and defoliation in cool, cloudy weather. Bordeaux mixture is both unsightly and harmful, unless used in very weak dilution. At strengths recommended for vegetables it will quickly turn rose leaves yellow and make them drop off. Dusts containing more than 3 to 4% metallic copper are injurious under some weather conditions. Dusting sulfur fine enough to pass through a 325-mesh screen has been successfully used for years for blackspot control, but in hot weather it burns margins of leaves. Copper and sulfur have a synergistic effect; a mixture of the two is more effective than either used alone, but such a mixture also combines injurious effects.

There are literally hundreds of combination rose sprays and dusts on the market under brand names, and it seems to me easier, and even cheaper, considering the time saved, for home gardeners to make use of them to control blackspot and other rose diseases as well as insects in one operation. You will have to determine by trial and error the best combination for your area, and you may not find one that combines remedies for all the pests you may have to fight through the season. Choose one that contains ingredients required every week all summer, and then add other chemicals if and when necessary. Whatever mixture is chosen, coverage should be complete on upper and lower leaf surfaces, and applications must be repeated at approximately weekly intervals. This may mean every 5 or 6 days when plants are growing rapidly in a rainy spring and perhaps every 7 to 9 days in dry weather, when growth is slow. Intervals of 10 to 14 days between sprays seldom give adequate control. Most directions call for application ahead of rain so that the foliage will be protected when spores germinate during the rain; but if sprays are applied every 7 days, there will always be enough residue left on the foliage to give protection during the next rain. It is not necessary to make an additional application immediately after a rain if your spraying is on a regular basis.

BLIGHTS

According to Webster, blight is "any disease or injury of plants resulting in withering, cessation of growth and death of parts, as in leaves, without rotting." The term is somewhat loosely used by pathologists and gardeners to cover a wide variety of diseases, some of which may have rotting as a secondary symptom. In general, the chief characteristic of a blight is sudden and conspicuous leaf and fruit damage, in contradistinction to leaf spotting, where dead areas are definitely delimited, or to wilt due to a toxin or other disturbance in the vascular system. Fire blight, discussed under Bacterial Diseases, is a typical blight, with twigs and branches dying back but holding withered, dead foliage.

Alternaria

Deuteromycetes, Hyphomycetes

Dark, muriform conidia formed in chains, simple or branches, or sometimes singly, on dark, simple conidiophores growing from dark hyphae (see Fig. 3.9). The apical portion of each conidium is narrowed and often elongated, bearing at its tip the next ovoid, tapering conidium. Species with this characteristic formerly placed in *Macrosporium* are now in *Alternaria*; those with spores rounded at both ends have been transferred to *Stemphylium*.

There are many saprophytic species in *Alternaria*, the spores of which are wind-borne for many miles and are a common cause of hayfever. There are also parasitic forms causing blights and leaf spots. Sometimes the disease starts as a leaf spot, but the lesions, typically formed in concentric circles, run together to form a blight, the dark conidia making the surface appear dark and velvety.

Alternaria alternata. **Blight, Foliage** and **Pod** of pea.

Alternaria cassiae. **Seedling Blight** of *Cassia* (sicklepod, and coffee senna), and showy crotalaria.

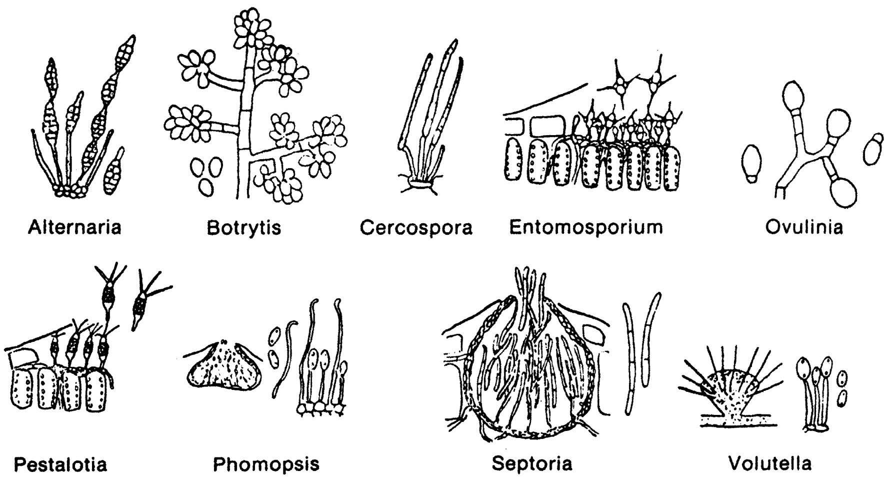


Figure 3.9 Conidial Production Among Some Fungi Causing Blights. *Alternaria*, dark muriform spores in chains; *Botrytis*, hyaline spores in clusters; *Cercospora*, pale to dark septate spores on dark conidia protruding from stomata; *Entomosporium*, peculiarly appendaged spores in acervulus; *Ovulina*, hyaline spore with basal disjunctor cell, borne free on mycelium; *Pestalotia*, in acervulus, median cells colored, end cells hyaline, apical cell with appendages; *Phomopsis*, oval and filiform hyaline spores in pycnidium; *Septoria*, septate hyaline spores in Pycnidium; *Volutella*, hyaline spores formed on a hairy sporodochium

Alternaria cucumerina. **Alternaria Blight** of Cucurbits, **Cucumber Blight**, **Black Mold**, general on cucumbers, muskmelon, watermelon, and winter and summer squash. Symptoms appear in the middle of the season, first nearest the center of the hill. Circular brown spots with concentric rings are visible only on upper surface of leaves, but a black, moldy growth, made up of conidiophores and large brown spores, can be seen on both leaf surfaces. Leaves curl and dry up, cantaloupe foliage being more sensitive than that of other cucurbits. The disease spreads rapidly in warm, humid weather, and, with the vines drying, the fruit is exposed to sunburn. Sunken spots develop on the fruit, covered with an olive green mass of conidia. Other species of *Alternaria* cause a decay of melons in transit and storage.

Control. Purdue 44 and some other varieties of muskmelon are rather resistant.

Alternaria dauci. **Alternaria Blight** of carrot, **Carrot Leaf Blight**, general on carrot and parsley. Affected leaves and petioles are spotted, then turn yellow and brown; entire tops are killed in severe infections. In California the disease is known as late blight, with the peak coming in November. The fungus apparently winters in discarded tops and on seed.

Control. Clean up refuse. Spray with a fixed copper spray or dust, starting soon after seedlings emerge and repeating at 7- to 10-day intervals.

Alternaria dianthicola. **Carnation Collar Blight**, **Leaf Spot**, **Stem and Branch Rot**, general on carnation, widespread on garden pinks and sweet william. The chief symptom is a blight or rot at leaf bases and around nodes, which are girdled. Spots on leaves are ashy white but centers of old spots are covered with dark brown to black fungus growth. Leaves may be constricted and twisted, the tip killed. Branches die back to the girdled area, and black crusts of spores are formed on the cankers. Conidia are spread during watering in the greenhouse or in rains, outdoors. Entrance is through wounds, stomata, or directly through the cuticle. The spores are carried on cuttings.

Control. Commercial growers can often avoid Alternaria blight by keeping plants growing continuously in the greenhouse. Cuttings should be disease-free, taken from midway up the stem, broken at the joint rather than cut, and started in sterilized soil. Ordinarily the foliage should be kept dry, but under mist propagation chemicals introduced into the mist system have reduced blight.

Alternaria helianthi. **Blight** and **Stem Lesion** of sunflower.

Alternaria panax. **Alternaria Blight**, **Root Rot**, **Leaf Spot** of ginseng, ming aralia, and goldenseal, generally distributed. In Ohio the disease appears each year in semiepidemic form and has been controlled with bordeaux mixture or a fixed copper spray plus a wetting agent, starting when plants emerge in early May and repeating every 2 weeks until 3 weeks after bloom.

Alternaria solani. **Early Blight** of potato and tomato, general on these hosts, occasional on eggplant and pepper. The pathogen was first described from New Jersey, in 1882.

Leaf symptoms are dark brown, circular to oval spots, marked with concentric rings in a target effect, appearing first on lower, shaded foliage, with the spots growing together to blight large portions or all of leaves, exposing fruits. There may be a collar rot of young tomato seedlings, sunken spots or cankers on older stems, blossom-drop with loss of young fruits, or dark leathery spots near the stem end of older fruits. Alternaria blight is the most common leaf spot disease of tomatoes in the Central and Atlantic States but is somewhat less important elsewhere.

Foliage symptoms on potato are similar to those on tomato. Small round spots on tubers afford entrance to secondary rot organisms. Each leaf spot may produce three or four crops of dark spores, which remain viable more than a year. They are blown by wind, splashed by rain, sometimes transmitted by flea beetles. The fungus is a weak parasite, entering through wounds and thriving in warm, moist weather, with 85°F as optimum temperature. It can survive in soil as long as the host refuse is not completely rotted; it also winters on seed and on weed hosts.

Control. Plan, if possible, a 3-year rotation with crops not in the potato family; dig under diseased refuse immediately after harvest. Use seed from healthy tomatoes, or purchase plants free from collar rot.

Alternaria tagetica. **Blight** of marigold.

Alternaria tenuissima. **Alternaria Blight**, **Leaf Spot** of violet and pansy. Spots vary from greenish yellow to light buff with burnt amber margins. Brown patches run together to form large, blighted areas. Clean up and burn old leaves in fall.

Alternaria zinniae. **Zinnia Blight**, **Alternariosis** on zinnia. Small reddish brown spots with grayish white centers increase to irregular, large, brown, dry areas. Similar spots on stem internodes or at nodes may girdle the stem, with dying back of upper portions. Dark brown to black basal cankers with sunken lesions are common. Roots may turn dark gray, rot, and slough off. Small brown flower spots enlarge to include whole petals, causing conspicuous blighting. The fungus apparently winters on seed and in soil.

Control. Clean up refuse; use a long rotation if growing plants commercially.

Ascochyta

Deuteromycetes, Coelomycetes

Pycnidia dark, globose, separate, immersed in host tissue, ostiolate; spores two-celled, hyaline ovoid to oblong.

Ascochyta asparagina. **Stem Blight** of asparagus fern. Small branchlets dry and drop prematurely; small branches are killed if attacked at crown.

Ascochyta chrysanthemi (*Mycosphaerella ligulicola*). (see *Phoma chrysanthemi* (*Didymella ligulica*)). **Ascochyta Ray Blight** of chrysanthemum, a conspicuous and rapid disease of ray flowers.

Ascochyta fabae f. sp. **spiricia**. **Leaf Blight** of vetch.

Ascochyta piniperda. **Spruce Twig Blight** on young shoots of red, Norway, and blue spruce; apparently a minor disease.

Ascochyta pisi, **A. pinodes**, **A. pinodella**. **Ascochyta Blight** or **Mycosphaerella Blight** of peas. All three fungi may be connected with the disease complex known as Ascochyta blight, are carried in infected seed and overwinter in plant debris. *A. pinodes* has *Mycosphaerella pinodes* as its ascospore stage so that the life cycle can start from either pycnidia or perithecia produced on plants or stubble.

Lesions begin as small purplish specks on leaves and pods. When infection is caused by *M. pinodes* or *A. pinodella*, the specks enlarge to round, targetlike spots, which join together to form irregular, brownish purple blotches. *M. pinodes* often withers and distorts young pods; *A. pinodella* causes a severe foot rot, a dark region at the soil line. Elongated, purplish black stem lesions are common. *A. pisi* causes leaf spots with dark brown margins, stem and pod spots, but no foot rot.

Control. Use western-grown seed, usually free from the disease; clean up all pea refuse and use a 3- or 4-year rotation.

The host range now includes many plants such as carrot, banana, and foliage plants.

Phoma chrysanthemi (Telemorph, **Didymella ligulica**) (formerly *Ascochyta chrysanthemi* (telemorph, *Mycosphaerella ligulicola*)). **Ascochyta Ray Blight** of chrysanthemum, a conspicuous and rapid disease of ray flowers. If young buds are infected, the head does not open; if the attack is later, there may be one-sided development of flowers. A tan or brown discoloration proceeds from the base toward the tip of each individual flower, followed by withering. Upper portions of stems and receptacles may turn black. Keep plants well spaced; avoid overhead watering and excessive humidity.

Balansia

Ascomycetes, Hypocreales, Clavicipitaccae.

Balansia cyperi. **Diseased Inflorescence**, **Blight** of purple nutsedge; fungus is systemic and transmitted through tubers.

Beniowskia

Deuteromycetes, Hyphomycetes

Hyphae are coiled at the periphery of mature sporodochia; spherical spores are borne on short denticles.

Beniowskia sphaeroidea. **Blight** of knotroot bristlegrass.

Botryodiplodia

Deuteromycetes, Coelomycetes

Pycnidia black, ostiolate, erumpent, stromatic, confluent; conidiosphores simple, short; conidia dark and 2- celled, ovoid to elongate

Botryosphaeria

Ascomycetes, Dothideales

Asci in locules in a stroma; spores one-celled, hyaline, eight in an ascus. There is a good deal of variation in the genus. The locules may be scattered throughout the stromatic tissue, or seated on the surface, or like perithecia, as in *Botryosphaeria ribis*. In *B. ribis* there are two pycnidial forms, a *Dothiorella* stage containing very small spores that may function as male cells and a *Macrophoma* stage containing larger spores, one-celled, hyaline, functioning as other conidia.

Botryosphaeria ribis var. **chromogena**. **Current Cane Blight**, **Canker**, **Dieback** of currant, flowering currant, gooseberry, apple, rose, and many other plants (also ► Cankers). There are two forms of this species, one being a saprophyte developing on already dying tissue. The parasitic form *chromogena* is so named from its developing a purple-pink color when grown on starch paste. There are also a number of pathogenic strains, varying from high to low in virulence. Some currant varieties are quite resistant, but the widely grown Wilder and Red Lake are rather susceptible.

Dieback and death of fruiting branches occur as the berries are coloring, with leaves wilting and fruit shriveling. Later in the season small, dark, wartlike fruiting bodies appear in rather definite parallel rows on the diseased canes. Rose canes show a similar dying back and wilting above a canker. The fungus winters in the canes; ascospores infect new shoots; secondary infection is by spores oozing from pycnidia. The mycelium grows downward through bark and wood to the main stem, which it encircles and kills.

Control. Cut out and burn diseased canes as soon as noticed. Take cuttings from healthy bushes.

Botryotinia

Ascomycetes, Helotiales, Sclerotiniaceae

Stroma a typical black sclerotium, loaf-shaped or hemispherical, just on or beneath cuticle or epidermis of plant and firmly attached to it; apothecia cupulate, stalked, brown; ascospores hyaline, one-celled; conidiophores and conidia of the *Botrytis cinerea* type.

Botryotinia fuckeliana. The apothecial stage of *Botrytis cinerea*, the connection having been made with isolates from grape, apple, celery, and potato. The name of the conidial stage is still widely used for the pathogen causing gray mold blights.

Botryotinia ricini. **Gray Mold Blight** of castor bean, **Soft Rot** of caladium. A pale to olive gray mold develops on castor-bean inflorescence, and when fading flowers drop onto stem and leaves, they are infected in turn.

Botrytis

Deuteromycetes, Hyphomycetes

Egglike conidia hyaline, one-celled, are formed on branched conidiophores over the surface, not in special fruiting bodies (see Fig. 3.9). The arrangement of the spores gives the genus its name, from the Greek *botrys*, meaning a cluster of grapes. Flattened, loaf-shaped, or hemispherical black sclerotia are formed on or just underneath cuticle or epidermis of the host and are firmly attached to it. These sclerotia, with a dark rind and light interior made up of firmly interwoven hyphae, serve as resting bodies to carry the fungus over winter. Microconidia, very minute spores that are spermatia or male cells, function in the formation of apothecia in the few cases where a definite connection has been made between the *Botrytis* stage and the ascospore form, *Botryotinia*.

Botrytis species are the common gray molds, only too familiar to every gardener. Some are saprophytic or weakIy parasitic on senescent plant parts on a wide variety of hosts; others are true parasites and cause such important diseases as peony blight, lily blight, tulip fire.

Botrytis cinerea. **Gray Mold Blight**, **Bud and Flower Blight** (see Fig. 3.10), **Blossom Blight**, **Gray Mold Rot**, **Botrytis Blight** of general distribution on a great many flowers, fruits and vegetables. There are undoubtedly many strains of this fungus and perhaps more than one species involved, but they have not been definitely separated.

This gray-mold disease is common on soft ripe fruits after picking, as any cook knows after throwing out half a box of strawberries or raspberries. But in continued humid weather the blight appears on fruits before harvest.

Figure 3.10 Botrytis Petal Spot on Magnolia

Blackberries in the Northwest are subject to gray mold. The fungus winters in blighted blueberry twigs, and spores infect blossom clusters.

Vegetables are commonly afflicted as seedlings grown in greenhouses and in storage after harvest. If lettuce plants are set in the garden too close together, they may blight at the base in moist weather, as will endive and escarole. Gray mold is common on lima beans, is sometimes found on snap and kidney beans. In rainy or foggy periods globe artichoke may be covered with a brownish gray, dusty mold, with bud scales rotten. Asparagus shoots are sometimes blighted, tomato stems rotted.

Some of the ornamentals on which *Botrytis cinerea* is troublesome are given in the following annotated list:

African violet – leaf and stem rot, cosmopolitan in greenhouses.

Amaryllis – gray mold, mostly in the South, on outdoor plants after chilling.

Anemone – occasional severe rotting of crowns.

Arborvitae – twig blight.
Aster – brown patches in flower heads of perennial aster; gray mold on flowers of China aster grown for seed in California.
Begonia – dead areas in leaves and flowers rapidly enlarging and turning black in a moist atmosphere; profuse brownish gray mold.
Calendula – gray-mold blight.
Camellia – flower and bud blight, common after frost.
Carnation – flower rot or brown spotting, worse in a cool greenhouse.
Century plant – gray mold after overwatering and chilling.
Chrysanthemum – cosmopolitan on flowers, buds, leaf tips, and cuttings. Ray blight on flowers starts as small, water-soaked spots, which rapidly enlarge with characteristic gray mold.
Dahlia – bud and flower blight.
Dogwood – flower and leaf blight. In wet springs anthers and bracts of aging flowers are covered with gray mold, and when these rot down on top of young leaves, there is a striking leaf blight.
Eupatorium – stem blight, common in crowded plantings. A tan area girdles stem near ground with tops wilting or drying to that point.
Geranium (*Pelargonium*) – blossom blight and leaf spot, most common in cool, moist greenhouses where plants are syringed frequently. Petals are discolored, flowers drop, gray mold forms on leaves.
Lily – *Botrytis cinerea* is common on lilies, but see also *B. elliptica*.
Marigold – gray mold prevalent on fading flowers.
Peony – late blight, distinguished from early blight (see *B. paeoniae*) by the sparse mold, usually standing far out from affected tissues, rather than a thick, short velvety mold, and by much larger, flatter sclerotia formed near base of the stalk. Late flowers are infected, and when they drop down onto wet foliage, irregular brown areas are formed in leaves.
Pine – seedling blight.
Pistachio – shoot blight.
Poinsettia – tip blight and stem canker.
Primrose – crown rot and decay of basal leaves, with prominent gray mold, very common in greenhouses where plants are heavily watered.
Rhododendron – flower, twig, and seedling blight.
Rose – bud or flower blight, cane canker. When half-open buds ball, the cause is often an infestation of thrips; but if gray mold is present, *Botrytis* is indicated. Canes kept too wet by a manure mulch, or wet leaves, or injured in some way, are often moldy.

Snapdragon – flower spikes wilt; tan cankers girdle stems.
Sunflower – bud rot and mold.
Sweet pea – blossom blight.
Viola spp. – gray mold and basal rot of violet and pansy.
Zinnia – petal blight, head blight, moldy seed.

Botrytis cinerea may also infect arabis, cineraria, eucharis, euphorbia, fuchsia, gerbera, gypsophila, heliotrope, hydrangea, iris, lilac, lupine, May-apple, pyrethrum, periwinkle, rose-of-Sharon, stokesia, viburnum, and wallflower.

Control. Sanitation is more important than anything else. Carry around a paper bag as you inspect the garden; put into it all fading flowers and blighted foliage; if infection is near the base, take the whole plant up for burning. Keep greenhouse plants widely spaced, with good ventilation; avoid syringing, overhead watering, and too cool temperature. Propagate cuttings from healthy plants in a sterilized medium.

Botrytis douglasii. **Seedling Blight** of giant sequoia and redwood, perhaps a form of *B. cinerea*.

Botrytis elliptica. **Lily Botrytis Blight**, general on lilies, also reported on tuberose and stephanotis in California. Lily species vary in susceptibility to the disease, but there are several strains of the fungus, and few lilies are resistant to all strains. Madonna lily, *L. candidum*, is particularly susceptible, with infection starting in autumn on the rosette of leaves developed at that time.

If the blight strikes early, the entire apical growth may be killed with no further development. More often the disease starts as a leaf spot when stems are a good height. Spots are orange to reddish brown, usually oval. In some species there is a definite red to purple margin around a light center; in others the dark margin is replaced by an indefinite water-soaked zone. If spots are numerous, they grow together to blight the whole leaf. Infection often starts with the lowest leaves and works up the stem until all leaves are blackened and hanging limp. This is the result of many spot infections and not from an invasion of the vascular system.

Buds rot or open to distorted flowers with irregular brown flecks. There are sometimes severe stem lesions, but the rot rarely progresses into the bulbs. Spores formed in the usual gray-mold masses in blighted portions are spread by rain, air currents, and gardeners. Optimum spore germination is in cool weather, around 60°F, but once infection has started 70°F promotes most rapid blighting. With sufficient moisture the cycle may repeat every few days through the season. The fungus winters as very small black sclerotia, irregular or elliptical in shape, in fallen flowers or blighted dead stems and leaves, or as mycelium in the basal rosette of Madonna lilies.

Control. Avoid too dense planting, and shady or low spots with little air circulation and subject to heavy dews. Clean up infected plant parts before sclerotia can be formed. Copper sprays are more effective for the lily *Botrytis* than the newer organics. Spray with bordeaux mixture; start when lilies are 5 or 6 inches high and continue at 10- to 14-day intervals until flowering.

Botrytis galanthina. **Botrytis Blight** of snowdrop, sometimes found in the sclerotial state on imported bulbs. If the black dots of sclerotia are present only on outer scales, remove scales before planting; otherwise discard bulbs.

Botrytis gladiolorum. **Gladiolus Botrytis Blight**, **Corm Rot**, first reported in Oregon in 1939 and now serious in all important gladiolus-growing areas – the Pacific Coast, the Midwest, Florida – in cool, rainy weather. In northern areas the disease is a corm-rotting problem, in the South a flower blight, damaging in transit, and in all areas it is a leaf spot or blight.

In dry weather and in more resistant varieties the leaf spots are very small, rusty brown, appearing only on the exposed side of the leaf. In more humid weather the spots are large, brown, round to oval or smaller, pale brown with reddish margins. Flower stems have pale brown spots that turn dark. There may be a soft rotting at the base of florets. The disease starts on petals as pinpoint, water-soaked spots, but in moist weather the whole flower turns brown and slimy. Flowers with no visible spotting when packed often arrive ruined. After the flowers are cut, infection spreads down the stalk and into the corm, producing dark brown spots, irregular in shape and size, most numerous on the upper surface. Corms may become soft and spongy with a whitish mold. Oval, flat, black sclerotia, 1/8 to 1/4 inch long, are formed on corms in storage and in rotting tissue in the field or in refuse piles. They may persist in the soil several years.

Control. Cure corms rapidly after digging; bury or burn all plant refuse.

Botrytis hyacinthi. **Hyacinth Botrytis Blight** recently found in Washington on plants grown from imported bulbs. Leaves have brown tips with gray mold or brown spots on lower surface. Leaves may be killed, with small black sclerotia formed in rotting tissue. Flowers rot and are covered with powdery gray spores. Do not work with plants when they are wet; remove infected parts or whole plants.

Botrytis narcissicola. ►*Sclerotinia narcissicola,* under Rots.

Botrytis paeoniae. **Peony Botrytis Blight**, **Early Blight**, **Bud Blast**, **Gray Mold**, probably present wherever peonies are grown. It is also recorded on lily-of-the-valley, but that may be a form of *Botrytis cinerea*. Peony blight was first noticed in epiphytotic form in this country in 1897 and has been important in wet springs ever since.

Young shoots may rot off at the base as they come through the ground or when a few inches high, with a dense velvety gray mold on the rotting portions. This early shoot blight is far more common when the young stems are kept moist by having to emerge through a mulch of manure or wet leaves. Flowers are attacked at any stage. Buds turn black when they are very tiny, never developing, or they may be blasted when they are half open. If it is dry in early spring, infection may be delayed until flowers are in full bloom, at which time they turn brown. Infection proceeds from the flower down the stem for a few inches, giving it a brown and tan zoned appearance. Leaf spots develop when infected petals fall on foliage. Continued blighting of leaves through the summer and late blasting of flowers may be due to *Botrytis cinerea*, which produces a sparser mold and conidiophores projecting farther from the petal or leaf surface.

Conidia are blown by wind, splashed by rain, carried on gardeners' tools, and sometimes transported by ants. Secondary infection is abundant in cool moist weather. In late summer small, shiny black, slightly loaf-shaped sclerotia are formed near the base of stalks, just under the epidermis. They are quite different from the large, flat, black sclerotia often formed by *B. cinerea* on the same stalks.

Control. Sanitation is the most important step. Cut down all tops in autumn at ground level, or just below, to get rid of sclerotia wintering near base of stems. Burn this debris; never use it for a mulch. Avoid any moisture-retentive covering. If you insist on manure, apply it in a wide ring around the plant, well outside the area of emerging shoots. Go around with a paper bag periodically, cutting off for burning all blighted parts; never carry these parts loose through the garden for fear of shedding spores to healthy plants.

Botrytis polyblastis. ► *Sclerotinia polyblastis.*

Botrytis streptothrix (see *Streptobotrys arisaemae*) (teleomorph state *Streptotinia arisaemae*). **Leaf and Stalk Blight** of Jack-in-the-pulpit and golden club.

Botrytis tulipae. **Tulip Fire**, **Botrytis Blight** of tulips, general wherever tulips are grown, causing much damage in rainy springs. The first indication of disease is the appearance of a few malformed leaves and shoots among healthy tulips or large light patches resembling frost injury on leaves. Gray

Figure 3.11 Botrytis Blight on Tulip

mold forming on such blighted areas of plants grown from infected bulbs provides an enormous number of conidia to be splashed by rain to nearby tulips. Secondary infection appears as minute, slightly sunken, yellowish leaf spots, surrounded with a water-soaked area, and gray to brown spots on stems, often zonate, and resulting in collapse. Small white spots appear on colored flowers, brown spots on white petals (see Fig. 3.11); but with continued moisture the spots grow together, and in a day or so the fuzzy gray mold has covered rotten blooms and large portions of blighted leaves.

Very small, shiny black sclerotia are formed in leaves and petals rotting into the ground, or on old flower stems or bulbs. Sometimes the latter have yellow to brown, slightly sunken, circular lesions on outermost fleshy scales without the formation of sclerotia. Spring infection comes from spores produced on such bulbs or from sclerotia on bulbs or sclerotia left loose in the soil after infected tissues have rotted.

Control. Inspect all bulbs carefully before planting; discard those harboring sclerotia or suspicious brown lesions. It is wise, though seldom possible in a small garden, to plant new bulbs where tulips have not grown for 3 years. Plant where there is good air circulation. Make periodic inspections, starting early, removing into a paper bag plants with serious primary infection and blighted leaves. Cut off all fading flowers before petals fall; cut off all foliage at ground level when it turns yellow. Burn all debris.

Streptobotrys arisaemae (formerly *Botrytis streptothrix*) (teleomorph state *Streptotinia arisaemae*). **Leaf** and **Stalk Blight** of Jack-in-the-pulpit and golden club. This species has conidiophores with strikingly twisted branches, producing a reddish brown mat of conidia. Sclerotia are very small, seldom over 1/32 inch, black, shiny, and somewhat hemispherical.

Briosia

Deuteromycetes, Hyphomycetes

Conidia on synnemata or coremia, erect fascicles of hyphae ending in a small head; spores globose, dark, one-celled, catenulate (formed in chains).

Briosia azaleae (see *Pycnosystanus azalea*) (*Pycnostysanus azaleae*). **Bud and Twig Blight** of azalea and rhododendron, widespread but occasional.
Pycnosystanus azalea (formerly *Briosia azaleae*) (*Pycnostysanus azaleae*). **Bud and Twig Blight** of azalea and rhododendron, widespread but occasional. The disease was reported from New York in 1874 and, as a rhododendron bud rot, from California in 1920. It was particularly serious on Massachusetts azaleas in 1931 and 1939. Flower buds are dwarfed, turn brown and dry; scales are silvery gray. Twigs die when lateral leaf buds are infected. Successive crops of coremia are produced on old dead buds for as long as three years, the first crop appearing the spring after summer infection. The coremia heads are dark, and the buds look as if stuck with tiny, round-headed pins. Prune out and burn infected buds and twigs in late autumn and early spring. Spraying with bordeaux mixture before blossoming and at monthly intervals after bloom may be wise in severe cases.

Calonectria

► Cylindrocladium under Blights.
Calonectria colhounii. **Blight** on Leucospermum.

Cenangium

Ascomycetes, Helotiales

Apothecia small, brown to black, sessile or substipitate on bark; spores hyaline, elliptical, one-celled; paraphyses filiform.

Cenangium ferruginosum. **Pine Twig Blight**, **Pruning Disease**; **Cenangium Dieback** of fir and pine. The fungus is ordinarily saprophytic on native pines but may become parasitic when their vigor is reduced by drought. The disease is considered beneficial to ponderosa pine in the Southwest because it prunes off the lower branches; on exotic pines it can be damaging.

Infection starts near a terminal bud in late summer and progresses down a twig into a node, sometimes beyond into 2-year wood. The needles redden and die; they are conspicuous in spring but drop in late summer. Then brown to black apothecia with a greenish surface to the cup appear on twigs. Cut off and destroy infected twigs.

Cercospora

Deuteromycetes, Hyphomycetes

Conidia hyaline to pale to medium green or brown; long, usually with more than three cross walls; straight or curved, with the base obconate or truncate, tip acute to obtuse; thin-walled; not formed in a fruiting body but successively on slender conidiophores, which emerge in fascicles or groups from stomata and usually show joints or scars where conidia have fallen off successively. The conidiophores are always colored, olivaceous to brown, pale to very dark (Fig. 3.9).

This is the largest group of the Dematiaceae, with about 400 species, all parasitic, causing leaf spots or blights. The teleomorph state, when known, is *Mycosphaerella*.

Cercospora apii. **Early Blight** of celery, general on celery and celeriac, first noted in Missouri in 1884 and since found in varying abundance wherever celery is grown. The disease is most severe from New Jersey southward. The name is somewhat misleading; in Florida early blight rarely appears before the Septoria disease known as late blight. Foliage spots appear when plants are about 6 weeks old. Minute yellow areas change to large, irregular, ash gray lesions, covered in moist weather with velvety groups of conidiophores and spores on both sides of leaves. Sunken, tan, elongated spots appear on stalks just before harvest. The disease spreads rapidly in warm, moist weather, the spores being splashed by rain, carried with manure or cultivators, or blown by wind. The life cycle is completed in 2 weeks.

Control. Seed more than 2 years old is probably free from viable spores; other seed should be treated with hot water, 30 minutes at 118° to 120°F.

Bordeaux mixture and other copper sprays have been recommended. Spray applications should start soon after plants are set and be repeated weekly, or more often. Emerson Pascal is blight-resistant.

Cercospora carotae. **Early Blight** of carrot. Lesions on leaves and stems are subcircular to elliptic, pale tan to gray or brown or almost black; lobes or entire leaflets are killed. The disease is more severe on young leaves and builds up as the plant grows. Spores, produced on both leaf surfaces, are spread by wind.

Control. Rotate crops and clean up refuse.

Cercospora microsora. **Linden Leaf Blight**, general on American and European linden. Small circular brown spots with darker borders coalesce to form large, blighted areas, often followed by defoliation; most serious on young trees.

Cercospora sequoiae. **Arborvitae Blight**, **Fire Blight**, on oriental arborvitae and Italian cypress in the South; destructive in ornamental plants. First reported from Louisiana in 1943, the fungus was named as a new species of *Cercospora* in 1945, but it is nearer *Heterosporium* in spore character. Affected leaves and branchlets are killed, turn brown, and gradually fall off, leaving shrubs thin and ragged. The lower two-thirds of the bush is affected most severely, with a tuft of healthy growth at the top. When close to a house, the side away from the wall shows most symptoms. Plants crowded in nurseries are killed in 1 to 3 years, but in home gardens they may persist for years in an unsightly condition. Conidiophores in fascicles produce conidia after girdling cankers have killed the twigs. There is often a swelling above the girdle that resembles an insect gall.

Cercospora sordida (*Mycosphaerella tecomae*) (see *Pseudocercospora sordida*) **Trumpetvine Leaf Blight** from New Jersey to Iowa and southward.

Pseudocercospora sordida (formerly *Cercospora sordida*) (*Mycosphaerella tecomae*). **Trumpetvine Leaf Blight** from New Jersey to Iowa and southward. Small, angular, sordid brown patches run together; edge of leaflets may be purplish; the fungus fruits on underside of leaves. The blight is seldom important enough to warrant control measures.

Cercosporidium

Cercosporidium punctum. **Stem and Foliage Blight** of fennel.

Choanephora

Zygomycetes, Mucorales

Mycelium profuse; sporangia and conidia present; sporangiola lacking. Sporangium pendent on recurved end of an erect, unbranched sporangiophore with a columella, containing spores provided at both ends and sometimes at the side with a cluster of fine, radiating appendages. Conidia formed in heads on a few short branches or an erect conidiophore enlarged at the tip; conidia longitudinally striate, without appendanges.

Choanephora cucurbitarum. **Blossom Blight**, **Fruit Rot**, common on summer squash and pumpkin, occasional on amaranth, cowpea, cucumber, okra, and pepper; on sweetpotato foliage, on fading hibiscus, on vinca, and other flowers. This blight is often found in home gardens in seasons of high humidity and rainfall. Flowers and young fruits are covered with a luxuriant fungus growth, first white, then brown to purple with a definite metallic luster. The fruiting bodies look like little pins stuck through this growth. Both staminate and pistillate flowers are infected, and from the latter the fungus advances into young fruits, producing a soft wet rot at the blossom end. In severe cases all flowers are blighted or fruits rotted.

Control. Grow plants on well-drained land; rotate crops. Remove infected flowers and fruits as noticed.

Choanephora infundibulifera. **Blossom Blight** on hibiscus and jasmine. **Leaf Blight** on soybean.

Ciboria

Ascomycetes, Helotiales, Sclerotiniaceae

Stroma a dark brown to black sclerotium in catkins or seed, simulating in shape the stromatized organ and not resembling a sclerotium externally. Apothecia cupulate to shallow saucer-shaped; brown.

Ciboria acerina. **Maple Inflorescence Blight** on red and silver maple. Apothecia, developed in great numbers from stromatized inflorescences on ground beneath trees, start discharging spores when maple flowers appear overhead. Mycelium spreads through stamens, calyx, and bud scales until flower cluster drops.

Ciboria carunculoides. **Popcorn Disease** of mulberry, a southern disease, not very important. Sclerotia are formed in carpels of fruit, which swells to resemble popcorn but remains green.

Ciborinia

Ascomycetes, Helotiales, Sclerotiniaceae

Stroma a thin, flat, black sclerotium of discoid type in leaves; one to several stalked apothecia arise from sclerotia; apothecia small, brown, cupulate to flat when expanded.

Ciborinia erythronii and **C. gracilis**. **Leaf Blight** of erythronium. Flat black sclerotia are prominent in leaves.

Cladosporium

► Blotch.

Cladosporium cladosporioides. **Blossom Blight** on strawberry.

Colletotrichum

► Anthracnose.

Colletotrichum acutatum. **Twig Blight** and **Fruit Spot** on dogwood.
Colletotrichum gloeosporioides. **Seedling Blight** of papaya.
Colletotrichum dematium. **Twig Blight** on vinca.

Corticium

Basidiomycetes, Aphyllophorales

Hymenium or fruiting surface of basidia consisting of a single resupinate or horizontal layer. This genus has contained a rather heterogeneous collection of species; some of the more important have been transferred to the genus *Pellicularia*.

Corticium koleroga. **Thread Blight**. ► *Pellicularia koleroga.*
Corticium microsclerotia. **Web Blight**. ► *Pellicularia filamentosa.*
Corticium salmonicolor (see *Erythricium salmonicolor*). **Limb Blight** of fig, pear, apple in Gulf States.
Corticium stevensii. **Thread Blight**. ► *Pellicularia koleroga.*
Corticium vagum, now *Pellicularia filamentosa*, teleomorph state of *Rhizoctonia solani*, causing black scurf of potatoes and damping-off and root rot of many plants. See both *Pellicularia* and *Rhizoctonia* under Rots.

Erythricium salmonicolor (formerly *Corticium salmonicolor*). **Limb Blight** of fig, pear, apple in Gulf States. The spore surface is pinkish.

Coryneum

Deuteromycetes, Coelomycetes

Acervuli subcutaneous or subcortical, black, cushion-shaped or disc-shaped; conidiophores slender, simple; spores dark with several cross walls, oblong to fusoid; parasitic or saprophytic (see Fig. 3.15).

Coryneum berckmansii (see *Seimatosporium berckmansii*). **Coryneum Blight** of Oriental arborvitae, also on Italian cypress, causing serious losses in nurseries and home gardens in the Pacific Northwest.

Coryneum microstictum (see *Seimatosperium lichehnicola*). **Twig Blight** of American bladdernut.

Coryneum carpophilum (**Cladosporium beijerinckii**) (see *Stigmina carpophila*, Anamorph, *Cladosporium beijerinckii*). **Peach Shoot Blight**, **Coryneum Blight** of stone fruits, **Shot Hole**, **Fruit Spot**, **Winter Blight**, **Pustular Spot**, general on peach in the West, also on almond, apricot, nectarine, and cherry.

Seimatosporium berckmansii (formerly *Coryneum berckmansii*). **Coryneum Blight** of Oriental arborvitae, also on Italian cypress, causing serious losses in nurseries and home gardens in the Pacific Northwest. Small twigs or branches are blighted, turn gray-green then reddish brown; many small branchlets drop, leaving a tangle of dead gray stems; larger limbs may be girdled. Twigs are dotted with black pustules bearing five-septate spores. As new growth develops in blighted areas, the spores spread the disease to young contiguous foliage. Reinfection continues until the plant is so devitalized it dies. The fungus fruits only on scale leaves or young stems.

Control. Remove and destroy blighted twigs. Apply a copper spray in September to healthy bushes as a preventive spray; apply in September and repeat in late October to infected bushes.

Seimatosporium lichenicola (formerly *Coryneum microstictum*). **Twig Blight** of American bladdernut. Young twigs are killed; the fungus winters in acervuli on this dead tissue, and spores are disseminated in spring. Prune out and burn diseased twigs during the winter.

Stigmina carpophila (formerly *Coryneum carpophilum* (*Cladosporium beijerinckii*)). **Peach Shoot Blight**, **Coryneum Blight** of stone fruits, **Shot Hole**, **Fruit Spot**, **Winter Blight**, **Pustular Spot**, general on peach in the West, also on almond, apricot, nectarine, and cherry. Twig lesions are formed on 1 -year shoots, reddish spots developing into sunken cankers; fruit buds are invaded, and there is copious gum formation. Small spots are formed on foliage, dropping out to leave typical shot holes, followed by considerable defoliation.

Apricot buds are blackened and killed during winter; fruiting wood in peaches is killed before growth starts. In late rains leaves and fruit are peppered with small, round, dead spots. Fruit lesions are raised, roughened, scabby. The fungus winters in twigs, diseased buds and spurs.

Control. In California, the standard spray for peach is bordeaux mixture applied in autumn immediately after leaf fall and before the rainy season. On apricots additional sprays are suggested for late January and at early bloom. On almonds at least two spring sprays are recommended, one at the popcorn stage of bloom, the other at petal fall.

Cryptocline

Deuteromycetes, Coelomycetes

Cryptocline cinerescens. **Twig Blight** of oaks.

Cryptospora

Scomycetes, Amphisphaeriales

Perithecia immersed in a stroma, with long necks converging into a disc; ascospores long, filiform, hyaline; conidia on a stroma.

Cryptospora longispora (see *Servazziella longispora*). **Araucaria Branch Blight**.

Servazziella longispora (formerly *Cryptospora longispora*). **Araucaria Branch Blight**. Lower branches are attacked first, with disease spreading upward; tip ends are bent and then broken off; plants several years old may be killed. Prune off and burn infected branches.

Cryptostictis

Deutermycetes, Coelomycetes

Spores dark, with several cross walls, formed in acervuli.

Cryptostictis sp. **Twig Blight** of dogwood.

Curvularia

Deuteromycetes, Hyphomycetes

Conidiophores brown, simple or sometimes branched, bearing conidia successively on new growing tips; conidia dark, three- to five-celled, with end cells lighter, more or less fusiform, typically bent or curved with central cells enlarged; parasitic or saprophytic.

Curvularia cymbopogonis. **Blight** and **Leaf Spot** of itchgrass. Leafspots coalesce after 3 or 4 days to form larger lesions and final blighting symptoms.

Curvularia lunata (*C. trifolii* f. sp. *gladioli*). **Gladiolus Flower Blight** and **Leaf Spot**, **Curvularia Disease**. Suddenly, in 1947, a blight showed up in Florida as a serious threat to the gladiolus cut-flower industry, ruining hundreds of acres there and in Alabama in the next few months. The disease is now recorded as far north as New York and Wisconsin and on the Pacific Coast. The pathogen is usually identified as *Curvularia lunata*, known as a crop pest for many years, especially in the tropics, but studies indicate it is a special form of *C. trifolii*, cause of a leaf spot of clover.

Curvularia spots on leaf or stem are oval, tan to dark brown, showing on both sides of the leaf, bordered with a brown ring, slightly depressed and with a narrow yellowish region between the spot and normal green of the leaf. Tan centers of spots are covered with black spores resembling powder. Premature death comes when stems of young plants are girdled; florets fail to open when petioles are girdled.

Under favorable weather conditions tan spots on petals turn into a smudgy flower blight. Brown to black irregular lesions appear on corms of blooming stock and develop further in storage; the fungus survives in corms from one season to the next. This is a high temperature fungus, with optimum for growth 75° to 85°F and no infection under 55°F. A 13-hour dew period is sufficient moisture. Leaf spots show up in 4 to 5 days, spots on florets and stems in only 2 to 3 days. The complete life cycle is as short as a week in warm rainy weather, and the fungus can survive in the soil for 3 years. Many gladiolus varieties are more or less resistant; Picardy and some others are very susceptible.

Cylindrocladium

Deuteromycetes, Hyphomycetes

Conidiophores dichotomously branched; spores hyaline, two- or several-celled.

Cylindrocladium clavatum. **Blight** on bird-of-paradise.
Cylindrocladium scoparium. **Cylindrocladium Blight**. Damping-off of seedlings and cuttings – conifers, azalea, magnolia, hydrangea, holly, pyracantha, bottle brush, and poinsettia – in greenhouses under very moist conditions. Infected azalea leaves turn black, with petiole bases softened, and drop in a few days; the bark turns brown. Leaves and stems are covered with brownish mycelial strands and white powdery masses of conidia. Control by proper humidity and aeration.
Cylindrocladium avesiculatum. **Blight** and **Leaf Spot** of *Leucothoë axillaris*.

Cylindrosporium

Deuteromycetes, Coelomycetes

Acervuli subepidermal, white or pale, discoid or spread out; conidiophores short, simple; conidia hyaline, filiform, straight or curved, one-celled or becoming septate; parasitic on leaves. Many species have *Higginsia* or *Coccomyces* as a teleomorph state.

Cylindrosporium defoliatum. **Leaf Blight** of Hackberry. May cause defoliation but usually unimportant.
Cylindrosporium griseum. On western soapberry.
Cylindrosporium juglandis. On walnut.

Delphinella

Ascomycetes, Dothideales

Delphinella balsameae. **Tip Blight** of fir.

Dendrophoma

Deuteromycetes, Coelomycetes

Pycnidia dark or light brown, superfcial or submerged and erumpent; globose or elongate, ostiolate; conidiophores elongated, branched; conidia hyaline, one-celled, elongate to ellipsoid; parasitic or saprophytic.

Dendrophoma obscurans (see *Phomopsis obscurans*). **Strawberry Leaf Blight**, **Angular Leaf Spot**. The lesions are large, circular to angular, reddish purple, zonate with age, having a dark brown center, a light brown zone, and a purple border. Spots may extend in a V-shaped area from a large vein to edge of the leaf, with black fruiting bodies appearing in the central portion. Not serious before midsummer, the disease may be destructive late in the season. The fungus winters on old leaves.

Phomopsis obscurans (formerly *Dendrophoma obscurans*). **Strawberry Leaf Blight**, **Angular Leaf Spot**.

Diaporthe

Ascomycetes, Diaporthales

Perithecia in a hard black stroma made up of host and fungal elements, first immersed, then erumpent; ascospores fusoid or ellipsoid, two-celled, hyaline. Anamorph state a *Phomopsis* with two types of spores; alpha conidia, hyaline, one-celled ovate to fusoid, and beta conidia, curved or bent stylospores.

Diaporthe arctii. **Diaporthe Blight** of Larkspur, **Stem Canker**, on annual larkspur and delphinium. Lower leaves turn brown and dry but remain attached; brown lesions at base of stems extend several inches upward and down into roots. Scattered dark pycnidia are present in stems, petioles, leaf blades, and seed capsules, the latter probably spreading the blight. Crowns are sometimes developed in a cottony weft of mycelium; perithecia develop on decaying stems. Remove and destroy diseased plants; use seed from healthy plants.

Diaporthe phaseolorum. **Lima Bean Pod Blight**, **Leaf Spot**, apparently native in New Jersey, where it was first noticed in 1891, more abundant on pole than on bush beans. Leaf spots are large, irregular, brown, often with discolored borders and large black pycnidia formed in concentric circles in dead tissue. Necrotic portions may drop out, making leaves ragged.

Pod lesions spread; pods turn black and wilted, with prominent black pycnidia. Seeds are shriveled or lacking. Spores are produced in great numbers, are disseminated by wind and pickers, and enter through stomata or wounds. The disease is most severe along the coast; optimum temperature is around 80°F. The fungus is seed-borne, but most lima bean seed is produced where the disease does not occur. Use healthy seed; clean up refuse; rotate crops.

Diaporthe phaseolorum var. **sojae**. **Soybean Pod** and **Stem Blight**, widespread. This disease was formerly confused with the more acute stem canker caused by *D. phaseolorum* var. *caulivora* (► Rots). The pod blight is a slower disease, killing plants in later stages of development. It can be identified by the numerous small black pycnidia scattered over the pods and arranged in rows on stems. The blight is more serious in wet seasons. The fungus winters on the seed and on diseased stems in the field. Use clean seed; clean up plant refuse; rotate crops.

Diaporthe phaseolorum var. **caulivora**. **Stem Blight** of soybean; also causes pod and seedling blight, stem canker, and seed decay of soybean.

Diaporthe vaccinii. **Blueberry Twig Blight**. The same fungus that causes cranberry rot blights new shoots of cultivated blueberries, entering at tips, progressing toward the base, and ultimately girdling old branches. Pycnidia develop on leaves and dead twigs. The disease is seldom serious enough for control measures.

Diaporthe vexans. **Phomopsis Blight** of Eggplant, **Fruit Rot**, general in field and market, especially in the South. Destruction is often complete, with every above-ground part affected. Seedlings rot at ground level. The first leaf spots are near the ground, definite, circular, gray to brown areas with light centers and numerous black pycnidia. The leaves turn yellow and die. Stem cankers are constrictions or light gray lesions. Fruit lesions are pale brown, sunken, marked by many black pycnidia arranged more or less concentrically. Eventually the whole fruit is involved in a soft rot or shriveling. Spores winter on seed and in contaminated soil. There is no fungicidal control. Use resistant varieties Florida Market and Florida Beauty.

Dichotomophora

► Cankers.

Dichotomophora lutea. **Stem Blight**, of common parsley.

Didymascella (Keithia)

Ascomycetes, Phacidiales, Stictidiaceae

Apothecia brown, erumpent on leaves of conifers; spores dark, two-celled, ovoid; paraphyses filiform; asci two- to four-spored.

Didymascella thujina. **Arborvitae Leaf Blight**, **Seedling Blight** of arborvitae in eastern states and of giant arborvitae, sometimes called western red cedar. The fungus is a native of North America and occurs abundantly in the West, damaging seedlings and saplings, often killing trees up to 4 years old, if they are in dense stands in humid regions. Older trees do not die, but foliage appears scorched, particularly on lower branches, and young leaf twigs may drop. Cushionlike, olive brown apothecia embedded in leaf tissue, usually upper, are exposed by rupture of the epidermis. After summer discharge of spores (round, brown, unequally two-celled) the apothecia drop out of the needles, leaving deep pits.

Control. Spray small trees and nursery stock several times during summer and fall with bordeaux mixture.

Didymascella tsugae (see *Fobrella tsugae*). **Hemlock Needle Blight**. Needles of Canada hemlock turn brown and drop in late summer. Spores are matured in apothecia on fallen needles with new infection in spring. The damage is not heavy.

Fobrella tsugae (see *Didymascella tsugae*). **Hemlock Needle Blight**. Needles of Canada hemlock turn brown and drop in late summer.

Didymella

Ascomycetes, Sphaeriales, Mycosphaerellaceae

Perithecia (or perithecia-like stromata) membranous, not carbonaceous; innate; not beaked; paraphyses present; spores two-celled, hyaline.

Didymella applanata. **Raspberry Spur Blight**, **Purple Cane Spot**, **Gray Bark**, general on raspberries, also on dewberry, blackberry. Named because it partially or completely destroys spurs or laterals on canes. The disease, known in North America since 1891, may cause losses up to 75% of the crop of individual plants of red raspberries. Dark reddish or purple spots on canes at point of attachment of leaves enlarge to surround leaf and bud and may darken lower portion of cane. Affected areas turn brown, then gray.

If buds are not killed outright during the winter, they are so weakened that the next season's spurs are weak, chlorotic, seldom blossoming. Pycnidia of the anamorph *Phoma* state and perithecia are numerous on the gray bark; ascospores are discharged during spring and early summer; on germination they can penetrate unwounded tissue.

Control. Keep plants well-spaced, allowing plenty of sunlight for quick drying of foliage and canes. Remove infected canes and old fruiting canes after harvest. A delayed dormant spray of lime sulfur or Elgetol may be advisable, followed by two sprays of ferbam or bordeaux mixture, applied when new shoots are 6 to 10 inches high and 2 weeks later.

Didymella bryoniae. Gummy stem blight and fruit spot; of watermelon.

Didymosphaeria

Ascomycetes, Dothideales

Perithecia innate or finally erumpent; not beaked; smooth; paraphyses present; spores dark, two-celled.

Didymosphaeria populina (*Venturia populina, V. tremulae, V. macularis* also cause this disease). **Shoot Blight** of polar, **Leaf and Twig Blight**. Young shoots are blackened and wilted. In moist weather dark olive green masses of spores are formed on leaves.

Diplodia

Deuteromycetes, Coelomycetes

Pycnidia innate or finally erumpent; black, single, globose, smooth; ostiole present; conidiophores slender, simple; conidia dark, two-celled, ellipsoid or ovoid. Parasitic or saprophytic.

Some species cause twig blights which are not too important: **Diplodia coluteae** on bladder senna; **D. longispora** on white oak; **Sphaeropsis sapinea** (formerly *D. pinea*) on pine; **D. sarmentorum** on pyracantha. **Lasiodiplodia theobromae** (formerly *Diplodia natalensis*) (anamorph state of *Physalospora rhodina*) causes blight, stem gumming, or stem-end rot of melons, as well as twig blight of peach and citrus. See further under Rots.

Diplodia gossypina (see *Lasiodiplodia theobromae*). **Blight** of slash pine and loblolly pine seedlings.

Lasiodiplodia theobromae (formerly *Diplodia gossypina*). **Blight** of slash pine and loblolly pine seedlings

Discula

Deuteromycetes, Coelomycetes

Discula quercina, **Twig Blight** of oaks.

Dothistroma

Deuteromycetes, Coelomycetes

Stroma dark, elongate, innate, becoming erumpent and swollen, with a stalk extending into the substratum, composed internally of dense, vertical hyphae; locules separate, one to several in the upper part of the stroma; conidiophores simple, slender; conidia several-celled, hyaline, long-cylindrical to filiform.

Dothistroma pini. **Needle Blight** on Austrian pine and red pine.

Cryphonectria (Endothia)

Ascomycetes, Diaporthales

Perithecia deeply embedded in a reddish to yellow stroma, with long necks opening to the surface but not beaked; paraphyses lacking; spores two-celled, hyaline. Conidia borne in hollow chambers or pycnidia in a stroma and expelled in cirrhi.

Cryphonectria parasitica. **Chestnut Blight**, **Endothia Canker**, general on chestnut. To most gardeners this disease is of only historical importance, for practically all of our native chestnuts are gone. The disease, however, persists in sprouts starting from old stumps and in the chinquapin. One of the most destructive tree diseases ever known, chestnut blight at least served to awaken people to the importance of plant disease and to the need for research in this field.

First noticed in the New York Zoological Park in 1904, the blight rapidly wiped out the chestnut stands in New England and along the Allegheny and Blue Ridge Mountains, leaving not a single undamaged tree. In 1925 the disease eliminated chestnuts in Illinois and by 1929 had reached the Pacific Northwest.

Conspicuous reddish bark cankers are formed on trunk and limbs, often swollen and splitting longitudinally. As the limbs are girdled, the foliage blights, so that brown, dried leaves are seen from a distance. The fungus fruits abundantly in crevices of broken bark, first producing conidia extruded in yellow tendrils from reddish pycnidia and later ascospores from perithecia embedded in orange stromata. Fans of buff-colored mycelium are found under affected bark.

Ascospores can be spread many miles by the wind, landing in open wounds, but the sticky conidia are carried by birds and insects. The fungus can live indefinitely as a saprophyte, and new sprouts developing from old stumps may grow for several years before they are killed.

Control. All eradication and protective measures have proved futile. Hope for the future lies in cross-breeding resistant Asiatic species with the American chestnut (and there has been some success in this line) or in substituting Chinese and Japanese chestnuts for our own.

Diplocarpon (Fabraea)

Ascomycetes, Helotiales, Dermateaceae

Apothecia develop on fallen leaves; small, disclike, leathery when dry, gelatinous when wet; asci extend above the surface of the disc; ascospores two-celled, hyaline. The anamorph stage an *Entomosporium* with distinctive cruciate four-celled conidia, each cell with an appendage, formed in acervuli (Fig. 3.9).

Didymascella tsugae (see *Fabrella tsugae*). **Hemlock Needle Blight**. Needles of Canada hemlock turn brown and drop in late summer.

Diplocarpon mespili (*Entomosporium mespili*) (formerly *Fabraea maculate*, **Entomosporium maculatum**). **Pear Leaf Blight**, **Entomosporium Leaf Spot**, **Fruit Spot**, generally distributed on pear and quince, widespread on amelanchier, sometimes found on apple, Japanese quince, medler, mountain-ash, Siberian crab, cotoneaster, loquat, photinia.

Pears may be affected as seedlings in nurseries or in bearing orchards. Very small purple spots appear on leaves, later extending to a brownish circular lesion, 1/4 inch or less in diameter, with the raised black dot of a fruiting body in the center of each spot. If spots are numerous, there is extensive defoliation. Fruit spots are red at first, then black and slightly sunken; the skin is roughened, sometimes cracked. Quince has similar symptoms.

Twig lesions appear on the current season's growth about midsummer, indefinite purple or black areas coalescing to form a canker. Primary spring infection comes more from conidia produced in these twig lesions than from ascospores shot from fallen leaves on the ground. Most commercial varieties of pear and quince are susceptible, although some are moderately resistant.

Fabraea maculate, **Entomosporium maculatum** (► *Diplocarpon mespili, Entomosporium mespili*). **Pear Leaf Blight**, **Entomosporium Leaf Spot**, **Fruit Spot**, generally distributed on pear and quince, widespread on amelanchier, sometimes found on apple, Japanese quince, medler, mountain-ash, Siberian crab, cotoneaster, loquat, photinia.

Fabraea thuemenii (*Entomosporium thuemenii*). **Hawthorn Leaf Blight**, wide-spread on *Crataegus* species. Symptoms are similar to those of pear leaf blight and for a long time the pathogen was considered identical. Small dark brown or reddish brown spots, with raised black dots, are numerous over leaves, which drop prematurely in August. In wet seasons trees may be naked by late August.

Control. Because the fungus winters in twig cankers as well as in fallen leaves, sanitation has little effect. Standard recommendation has been to spray three times with bordeaux mixture, starting when leaves are half out and repeating at 2-week intervals. The copper may be somewhat phytotoxic, causing small reddish spots similar to those of blight, but it does prevent defoliation.

Fabrella tsugae (formerly *Didymascella tsugae*). **Hemlock Needle Blight**. Needles of Canada hemlock turn brown and drop in late summer. Spores are matured in apothecia on fallen needles with new infection in spring. The damage is not heavy.

Furcaspora

Deuteromycetes, Coelomycetes

Starlike botryoblastospores; acervuli become erumpent at maturity and grade into sporodochia and pycnidia.

Furcaspora pinicola. **Needle Cast** of pine.

Fusarium

► Rots.

Fusarium graminearum. **Head Blight** of wild rice.
Fusarium moniliforme var. **subglutinans**. **Blight** of slash pine and loblolly pine seedlings.
Fusarium solani. **Stem and Leaf Blight** on Spanish moss.
Fusarium subglutinans. **Foliar Blight** and **Collar Rot** on Chinese evergreen. **Seedling Blight** on pine.
Fusarium tabacinum. **Stem Blight** of squash and pumpkin.

Gibberella

Ascomycetes, Hypocreales, Nectriaceae

Perithecia superficial, blue, violet, or greenish; spores hyaline with several cells. Conidial stage in genus *Fusarium* with fusoid curved spores, several-septate. The species causing stalk rots of corn and producing gibberellic acid are more important than those causing blights.

Gibberella baccata (*Fusarium lateritium*). **Twig Blight** of ailanthus, citrus, cotoneaster, fig, hibiscus, hornbeam, peach, and other plants in warm climates, sometimes associated with other diseases.

Glomerella

► Anthracnose.

Glomerella cingulata. **Cyclamen Leaf** and **Bud Blight Leaf** and **Shoot Blight** of poplar.

Gnomonia

► Anthracnose.

Gnomonia rubi. **Cane Blight** of blackberry, dewberry, raspberry.

Hadrotrichum

Deuteromycetes, Hyphomycetes

Sporodochia cushion-shaped, dark; conidiophores dark, simple, forming a palisade and arising from a stroma-like layer; conidia dark, nearly spherical, one-celled, borne singly; parasitic on leaves.

Hadrotrichum globiferum. **Leaf Blight** of lupine.

Helminthosporium

Deuteromycetes, Hyphomycetes

Mycelium light to dark; conidiophores short or long; septate, simple or branched, often protruding from stomata of host; more or less irregular or bent, bearing conidia successively on new growing tips; conidia dark typically with more than three cells, cylindrical or ellipsoid, sometimes slightly curved or bent, ends rounded. Parasitic, often causing leaf spots or blights of cereals and grasses.

Helminthosporium catenarium (*Drechslera catenaria*). **Leaf Blight** or **Crown Rot** on creeping bentgrass; red leaf lesions and leaf tip dieback; eventually entire plant becomes blighted to crown.

Helminthosporium gigantea (*Drechslera gigantea*). **Blight** or **Zonate Leaf Spot** on wild rice and grasses.

Helminthosporium maydis (*Cochliobolus heterostrophus*). **Southern Corn Leaf Blight**, easily confused with southern corn leaf spot due to *H. carbonum*. The leaf blight occurs throughout the corn areas of the South and north to Illinois, more important on field than on sweet corn. Grayish tan to straw-colored spots with parallel sides unite to blight most of the leaf tissue. The fields appear burned by fire. Resistant varieties offer the only control.

Helminthosporium turcicum (see *Setosphaeria turcica*). **Northern Corn Leaf Blight** on field and sweet corn and on grasses; found from Wisconsin and Minnesota to Florida but more severe in states with heavy dews, abundant rainfall, and warm summers, losses running from a trace to 50%.

Setosphaeria turcica (formerly *Helminthosporium turcicum*). **Northern Corn Leaf Blight** on field and sweet corn and on grasses; found from Wisconsin and Minnesota to Florida but more severe in states with heavy dews,

abundant rainfall, and warm summers, losses running from a trace to 50%. The disease starts on the lower leaves and progresses upward. Small, elliptical, dark grayish green, water-soaked spots turn greenish tan and enlarge to spindle-shape, 1/2 to 2 inches wide, 2 to 6 inches long. Spores developing on both leaf surfaces after rain or heavy dew give a velvety dark green appearance to the center of the lesions. Whole leaves may be killed; entire fields turn dry. The fungus winters in corn residue in the field and produces spores the next spring; these are spread by wind.
Control. Use a 3-year or longer rotation.

Herpotrichia

Ascomycetes, Dothidiales

Mycelium dark, perithecia superficial; spores with several crosswalls, olivaceous when mature.

Herpotrichia juniperi. **Brown Felt Blight** of conifers at high elevations; on fir, juniper, incense cedar, spruce, pine, yew when under snow. When the snow melts, lower branches are seen covered with a dense felty growth of brown to nearly black mycelium, which kills foliage by excluding light and air as well as by invading hyphae. Small, black perithecia are scattered over the felt. This pathogen also found on dwarf mistletoe.

Heterosporium

Deuteromycetes, Hyphomycetes

Conidiophores dark, simple, bearing conidia successively on new growing tips; conidia dark, with three or more cells, cylindrical, with rough walls (echinulate to verrucose); parasitic, causing leaf spots, or saprophytic.

Heterosporium syringae. **Lilac Leaf Blight**. A velvety, olive green bloom of spores if formed in blighted, gray-brown leaf areas, which may crack and fall away. Infection is on mature leaves and the fungus is often associated with *Cladosporium*. If necessary, spray after mid-June with bordeaux mixture.

Higginisia

See *Coccomyces* under Leaf Spots.

Higginisia hiemalis. **Cherry Leaf Blight**. See *Blumeriella jaapi* and *Coccomyces biemalisi*, Cherry Leaf Spot.

Higginisia kerriae. **Kerria Leaf** and **Twig Blight**. See *Blumeriella kerriae* and Coccomyces kerriae under Leaf Spots.

Hypoderma

Ascomycetes, Rhytismatales

Ascospores formed in hysterothecia (elongated perithecia or apothecia) extending along evergreen needles; asci long-stalked; ascospores one-celled hyaline, fusiform, surrounded by a gelantinous sheath (see Fig. 3.29).

Hypoderma lethale (see *Ploidoderma lethale*). **Gray Leaf Blight** of hard pines, from New England to the Gulf States.

Ploioderma lethale (formerly *Hypoderma lethale*). **Gray Leaf Blight** of hard pines, from New England to the Gulf States. Hysterothecia are short, narrow, black; often seen on pitch pine.

Hypodermella

Ascomycetes, Rhytismatales

Like *Hypoderma* but one-celled spores are club-shaped at upper end, tapering toward base (see Fig. 3.29).

Hypodermella abietis-concoloris (see *Lirula abietis-concoloris*). **Fir Needle Blight** on firs and southern balsam.

Hypodermella laricis. **Larch Needle** and **Shoot Blight**. Yellow spots are formed on needles, which turn reddish brown but stay attached, giving a scorched appearance to trees. Hysterothecia are very small, oblong to elliptical, dull black, on upper surface of needles.

Lirula abietis-concoloris (formerly *Hypodermella abietis-concoloris*). **Fir Needle Blight** on firs and southern balsam.

Nectria (Hypomyces)

Ascomycetes, Hypocreales

Perithecia bright colored with a subicle (crustlike mycelial growth underneath); spores two-celled, light, with a short projection at one end.

Hypomyces ipomoeae (see *Nectria ipomoeae*). **Twig Blight** of bladdernut.
Nectria ipomoeae (formerly *Hypomyces ipomoeae*). **Twig Blight** of bladdernut.

Hyponectria

Ascomycetes, Hypocreales, Nectriaceae

Perithecia bright colored, soft; innate or finally erumpent; paraphyses lacking; spores one-celled, light-colored, oblong.

Hyponectria buxi. **Leaf Blight**, **Leaf Cast** of boxwood.

Itersonilia

Deuteromycetes, Hyphomycetes

Cells reproduciug by budding and germinating by repetition; clamp connections as in Basidiomycetes and probably anamorph species of *Tremellales*. The genus is not well understood.

Itersonilia perplexans. **Petal Blight** of chrysanthemum and China aster. The fungus was isolated from greenhouse chrysanthemums in Minnesota in 1951 but apparently has been present, as a parasite or saprophyte, on many other plants. On pompom chrysanthemums the tip half of outer petals turns brown and dries; the diseased tissue is filled with broad hyphae and clamp connections. Inoculated snapdragons show similar symptoms. Adequate greenhouse ventilation seems to prevent trouble. This fungus has also been reported on dill.
Itersonilia sp. **Leaf Blight**, **Canker** of parsnip, seasonal in New York and neighboring states. Plants are defoliated in cool, moist weather. Spores from leaves produce a chocolate brown dry rot on shoulder or crown of the root. Good drainage and long rotation aid in control.

Kellermannia

Deuteromycetes, Coelomycetes

Pycnidia black, globose, separate; immersed in host tissue; ostiolate; conidiophores short, simple; conidia hyaline, mostly two-celled, cylindrical with an awl-shaped appendage at the tip; parasitic or saprophytic.

Kellermania anomala (*K. yuccaegena.*) **Yucca Leaf Blight**, general on nonarborescent forms of yucca; in Florida and California on arborescent forms.

Kellermania sisyrinchii (see *Scolecosporiella sisyrinchii.*) **Leaf Blight** of blue-eyed grass.

Scolecosporiella sisyrinchii (formerly *Kellermannia sisyrinchii.*) **Leaf Blight** of blue-eyed grass.

Labrella

Deuteromycetes, Coelomycetes

Pycnidia with a radiate shield, rounded; innate or erumpent; spores hyaline, one-celled.

Labrella aspidistrae. **Leaf Blight** of aspidistra.

Leptosphaeria

Ascomycetes, Dothideales

Perithecia membranous, not beaked, opening with an ostiole; innate or finally erumpent; paraphyses present; spores dark, with several cells. Anamorph state a *Coniothryium* with black, globose pycnidia and very small, dark, one-celled conidia, extruded in a black cirrhus.

Diapleella coniothyrium (formerly *Leptosphaeria* (*Melanomma*) *conithyrium;* (*Coniothyrium fuckelii*)). **Raspberry Cane Blight**, general on raspberry, dewberry, blackberry. The same fungus causes cankers of apple and rose (► Cankers). On raspberry, brown dead areas extend into wood; whole canes or single branches wilt and die; often between blossoming and fruiting. The fungus enters the bark at any time during the season, through an insect wound or mechanical injury. Smutty patches on the bark come from small olive conidia of the *Coniothyrium* stage and larger, dark, four-celled ascospores. Ascospores are spread by rain; conidia by rain and insects.

Control. Sanitation is very important; cut out and burn all diseased canes. A control program for spur blight should suffice for cane blight.

Leptosphaeria (Melanomma) conithyrium (**Coniothyrium fuckelii**) (see *Diapleella coniothyrium*) **Raspberry Cane Blight**, general on raspberry, dewberry, blackberry.

Leptosphaeria korrae. **Blight** on turfgrass (associated with Fusarium blight syndrome); disease is also called spring dead spot.

Leptosphaeria thomasiana. **Cane Blight** of dewberry, raspberry, in Pacific Northwest.

Leptosphaeria sp. Blight; of Miscanthus.

Linospora

► Leaf Spots.

Linospora tetraspora. **Leaf Blight** of poplar.

Lophodermella

Ascomycetes, Rhytismatales

Hymenium on a fleshy-gelatinous stroma under the bark of woody plants; ascospores aseptate.

Lophodermella sp. **Needle Cast** of pine.

Macrophomina

► Rots.

Macrophomina phaseolina. **Ashy Stem Blight**, **Charcoal Rot** of soybeans, sweetpotatoes, many other plants. ► Rots.

Micropeltis

Ascomycetes, Dothideales

A single hymenium, fruiting layer, covered with an open, reticulate scutellum; paraphyses present; spores hyaline, with several cells.

Micropeltis viburni. **Leaf Blight** of viburnum.

Monilinia (Sclerotinia)

Ascomycetes, Helotiales, Sclerotiniaceae

Stroma is a sclerotium formed in fruit by the fungus digesting fleshy tissues and replacing them with a layer of broad, thick-walled, interwoven hyphae forming a hollow sphere enclosing core or seed of fruit, which has become a dark, wrinkled, hard mummy. Apothecia funnel-form or cupulate, rarely flat-expanded, some shade of brown; asci eight-spored; ascospores one-celled, ellipsoidal, often slightly flattened on one side, hyaline. Conidia hyaline, one-celled, formed in chains in grayish masses called sporodochia.

Monilinia azaleae. **Shoot Blight** of native or pinxter azalea (*Rhododendron roseum*). Apothecia are formed on overwintered mummied fruits (capsules) in leaf mold under shrubs in moist places. Ascospores infect leaves and succulent shoots when the azalea is in full bloom. The conidial stage is common on young developing fruits in late June and July (New York).
Monilinia fructicola. **Leaf Blight** and **Shoot Blight** of peach.
Monilinia johnsonii. **Leaf Blight**, **Fruit Rot** of hawthorn.
Monilinia laxa. **Blossom Blight**, **Brown Rot** of apricot, almond, cherry, plum, and prune on Pacific Coast. Blossoms and twigs are blighted with a good deal of gum formation. *Monilinia laxa* is sometimes coincident with, and confused with, *M. fructicola*, which causes a more general rot of stone fruits. Both are discussed more fully under Rots.
Monilinia rhododendri (*Sclerotinia seaveri*). **Twig Blight**, **Seedling Blight** of sweet cherry.

Mycosphaerella

► Anthracnose.

Mycosphaerella citrullina (*M. melonis*) conidial stage *Didymella bryoniae*. **Gummy Stem Blight**, **Stem End Rot**, **Leaf Spot** of watermelon,

muskmelon, summer squash, pumpkin, and cucumber. Gray to brown dead areas in leaves are marked with black pycnidia; leaves may turn yellow and shrivel. Stem infection starts with a water-soaked oily green area at nodes. The stem is girdled, covered with a dark exuded gum, and the vine wilts back to that point. Fruit rot starts gray, darkens to nearly jet black, with gummy exudate.
Control. Clean up crop refuse; practice rotation. Some varieties are more resistant than others.
Mycosphaerella fijiensis. **Black Sigatoka** on dwarf banana in FL.
Mycosphaerella melonis. **Gummy Stem Blight** of cucumbers.
Mycosphaerella pinodes. **Pea Blight**. ► *Ascochyta pinodes*.
Mycosphaerella rabiei (Anamorph, *Phoma rabiei*). **Blight** of chickpea
Mycosphaerella sequoiae. **Needle Blight** of redwood.

Myriogenospora

Ascomycetes, Hypocreales

Ascomata superficial or in a stroma, fleshy, bright-colored; ascus with a thick cap traversed by a slender pore; ascospores filifrom, multiseptate, often fragmenting.

Myriogenospora atramentosa. **Blight** on turf grass, centipedegrass.

Mystrosporium

Deuteromycetes, Hyphomycetes

Conidia dark, muriform; hyphae long.

Bipolaris iridis (formerly *Mystrosporium adustum*). **Leaf Blight**, **Ink Spot** of bulbous iris; also on montbretia and lachenalia. Irregular black patches or blotches appear soon after leaves push through the ground; under moist conditions the foliage withers and dies prematurely. Inky black stains appear on husks of bulbs (usually *Iris reticulata*), and yellow dots or elongated sunken black craters show on fleshy scales. The bulbs may rot,leaving only the husk and a mass of black powder. The fungus spreads through the soil, invading adjacent healthy bulbs.
Control. Dig bulbs every year; discard all diseased bulbs and debris; plant in a new location. Spray with bordeaux mixture.

Mystrosporium adustum (see *Bipolaris iridis*). **Leaf Blight**, **Ink Spot** of bulbous iris; also on montbretia and lachenalia.

Myxosporium

Deuteromycetes, Coelomycetes

Conidia hyaline, one-celled, in discoid to pulvinate acervuli on branches.

Myxosporium diedickei. **Twig Blight** of mulberry.
Myxosporium everhartii. **Twig Blight** of dogwood. **M. nitidum**. Twig blight and dieback of native dogwood. Prune twigs back to sound wood; feed and water trees.

Neopeckia

Ascomycetes, Dothideales

Perithecia hairy, not beaked, formed on a mycelial mass; paraphyses present; spores two-celled, dark.

Neopeckia coulteri. **Brown Felt Blight** on pines only, otherwise similar to brown felt blight caused by *Herpotrichia*, a disease of high altitudes on foliage under snow.

Ovulinia

Ascomycetes, Helotiales, Sclerotiniaceae

Stroma a sclerotium, thin, circular to oval, shallowly cupulate, formed in petal tissue but falling away; minute globose spermatia; apothecia of *Sclerotinia* type, small; asci eight-spored; paraphyses septate with swollen tips; conidia large, obovoid, one-celled except for basal appendage or disjunctor cell; borne singly at tips of short branches of mycelium forming a mat over surface of petal tissue (see Fig. 3.9).

Ovulinia azaleae. **Azalea Flower Spot**, **Petal Blight**, very destructive to southern azaleas in humid coastal regions, occasional on mountain-laurel and rhododendron. Starting as a sudden outbreak near Charleston, South Carolina, 1931, the disease spread rapidly north of Wilmington, North Carolina, down the coast to Florida, and around the Gulf. It reached Texas by 1938 and was in California by 1940; it was reported in Maryland in 1945, in Virginia in 1947, and in Philadelphia in 1959. Petal blight was reported from a Long Island, New York, greenhouse in 1956, apparently present there since 1952, and in 1959 infected all the azaleas in one New Jersey greenhouse. In both cases the blight started on plants purchased from the South. This is the most spectacular disease that I have ever witnessed, with most of the bloom on all the azaleas in a town blighting simultaneously and seemingly overnight under special weather conditions. The blight does not injure stem or foliage; it is confined to the flowers. The loss is aesthetic and economic from the standpoint of tourist trade. For many years, before a control program was worked out, the great azalea gardens of the South had to close their gates to visitors far too early in the season.

Primary infection comes from very small apothecia produced from sclerotia on the ground under shrubs, usually in January or February, occasionally as early as December. Spores shot into the air are carried by wind drift to flowers near the ground of early varieties, initial spots being whitish. If you put your finger on such a spot, the tissue melts away. With continued high humidity, heavy fog, dew, or rain, conidia are produced over the inner surfaces of petals and are widely disseminated to other petals by wind, insects, and splashed rain. Within a few hours colored petals are peppered with small white spots, and white flowers have numerous brown spots. By the next day flowers have collapsed into a slimy mush, bushes looking as if they had had scalding water poured over them. If the weather stays wet, small black sclerotia are formed in the petals in another 2 or 3 days. Infected blooms seldom drop normally but remain hanging on the bushes in an unsightly condition for weeks and months, some even to the next season. Many of the sclerotia, however, drop out and remain in the litter on the ground ready to send up apothecia the next winter.

Both Indian and Kurume varieties are attacked, the peak of infection coming with mid-season varieties such as Pride of Mobile or Formosa. In some seasons dry weather during early spring allows a good showing of azaleas; in other years blight starts early and there is little color unless azaleas are sprayed. On Belgian azaleas in greenhouses blight may start in December.

Control. Some mulches and soil treatments will inhibit apothecial production. Secondary infection is bound to come from some untreated azalea in the neighborhood. Spraying gives very effective, even spectacular, control if started on time, when early varieties are in bloom and midseason azaleas are showing color. Sprays must be repeated three times a week as long as petal surface is expanding, about 3 or 4 weeks. After that, weekly spraying is sufficient. Spraying is mandatory now for the big azalea gardens, and the admission fees from the lengthened season pay for the program many times over.

The original successful formula was: Dithane D-14 (nabam) 1 1/3 quarts to 100 gallons water, plus 1 pound 25% zinc sulfate, 1/2 pound hydrated lime, and 1 ounce of spreader Triton B 1956. Later work showed that the lime could be omitted, Dithane reduced to 1 quart, and zinc sulfate to 2/3 pound to prevent injury in periods of drought. The spray should be a fine mist, applied from several directions to get adequate coverage.

Commercial growers should beware of ordering azaleas from the South unless they are bare-rooted and all flower buds showing color removed. As a matter of fact, any potted or balled and burlapped plant grown in a nursery near azaleas could very easily bring along some of the tiny sclerotia in the soil, and they might remain viable more than 1 year. All traces of soil should be washed off roots, and the plants wrapped in polyethylene for shipping.

Pellicularia

Basidiomycetes, Aphyllophorales

Includes some species formerly assigned to *Corticium, Hypochnus*, and *Peniophora*. Hyphae stout, very short-celled; mycelium branching at right angles; basidia very stout, formed on a resupinate, cottony or membranous layer of mycelium. Anamorph state a *Rhizoctonia*, with sclerotia made up of brown, thin-walled, rather angular cells, or *Sclerotium*, with sclerotia having a definite brown rind and light interior.

Athelia rolfsii (formerly *Pellicularia rolfsii* (Anamorph, *Sclerotium rolfsii*). **Southern Blight**, **Crown Rot**. The disease has been known, in its sclerotium stage, for many years on hundreds of plants. The connection with *Pellicularia* is recent, and the name does not have universal agreement. One strain of the fungus has been called *Sclerotium delphinii* in the North, where the disease is usually designated crown rot. This is, however, a variable fungus with single spore cultures from the *Pellicularia* stage producing sclerotia typical of *Sclerotium delphinii* and of *S. rolfsii*, with intermediate forms. Sclerotia of the southern blight strain are very small, round, tan, about the size, shape, and color of mustard seed, the pathogen being frequently called the mustard-seed fungus.

Southern blight affects almost all plants except field crops like wheat, oats, corn, and sorghum. Fruits and vegetables include Jerusalem artichoke, avocado, bean, beet, carrot, cabbage, cucumber, eggplant, endive, lettuce, melon, okra, onion, garlic and shallot, pea, peanut, pepper, potato, rhubarb, strawberry, sweetpotato, tomato, turnip, and watermelon. Ornamentals, too numerous to list in entirety, include ajuga, ageratum, amaryllis, azalea, caladium, calendula, campanula, canna, carnation, cosmos, China aster, chrysanthemum, dahlia, delphinium, daphne, duranta, gladiolus, hollyhock, hydrangea, iris, jasmine, lemon verbena, lily, lupine, marigold, morning-glory, myrtle, narcissus, orchids, phlox, pittosporum, rose, rose-mallow, rudbeckia, scabiosa, sedum, sweet pea, star-of-bethlehem, tulip, violet, and zinnia.

The first sign of blight is the formation of white wefts of mycelium at the base of the stem, spreading up in somewhat fan-shaped fashion and sometimes spreading out over the ground in wet weather. The sclerotia formed in the wefts are first white, later reddish tan or light brown. They may be numerous enough to form a crust over the soil for several inches around a stem, or they may be somewhat sparse and scattered.

In the white stage, droplets of liquid often form on the sclerotia, and the oxalic acid in this liquid is assumed to kill plant cells in advance of the fungus hyphae. This means that the pathogen never has to penetrate living tissue and explains why so many different kinds of plants succumb so readily to southern blight. Fruits touching the ground, as well as vegetables with fleshy roots, like carrots and beets, or plants with bulbs or rhizomes, like onions, narcissus, and iris, seem particularly subject to this disease. Low ornamentals such as ajuga blight quickly, the whole plant turning black; tall plants like delphinium rot at the crown and then die back or topple over; bulbs have a cheesy interior, with sclerotia forming on or between the scales.

Control. Remove diseased plants as soon as they are noticed. Take out surrounding soil, for 6 inches beyond the diseased area, wrapping it carefully so that none of the sclerotia drop back. Increasing the organic content of the soil reduces southern blight, as does the addition of nitrogenous fertilizers, such as ammonium nitrate. Treating narcissus bulbs in hot water for 3 hours, as for nematodes, kills the fungus in all except the very largest bulbs.

Pellicularia filamentosa (see *Thanatephorus cucumeris*), teleomorph state of *Rhizoctonia solani*. This is a variable fungus with some strains or forms causing leaf blights but best known as cause of Rhizoctonia rot of potatoes and damping-off of many plants. ►Rots.

Pellicularia filamentosa f. sp. **microsclerotia** (*Corticium microsclerotia*) see *Thanatephorus cucumeris*. **Web Blight** of snap bean, lima bean, also reported on fig, elder, hibiscus, hollyhock, tung oil, and phoenix tree, from Florida to Texas. Many small brown sclerotia and abundant weblike mycelium are found on bean stems, pods, and foliage. Infection starts with small circular spots that appear water-soaked or scalded. They enlarge to an inch or more, become tan with a darker border, are sometimes zonate. The whitish mycelium grows rapidly over the leaf blade, killing it, and spreads a web from leaf to leaf, over petioles, flowers, and fruit, in wet weather and at temperatures 70° to 90°F; in dry weather growth is inconspicuous except on fallen leaves. The fungus is spread by wind, rain, irrigation water, cultivating tools, and bean pickers; it survives in sclerotial form from season to season.

Control. Destroy infected plants; clean up refuse. In Florida, do not plant beans between June and September if web blight has been present. Use a copper spray or dust.

Pellicularia filamentosa f. sp. **sasakii**. See *Thanatephonus cucumeris*. **Leaf Blight** of grasses, clover, etc.

Pellicularia filamentosa f. sp. **timsii**. See *Thanatephonus cucumeris*. **Leaf Blight** of fig.

Pellicularia rolfsii. See *Athelia rolfsii*, Anamorph, ►*Sclerotium rolfsii*. **Southern Blight**, **Crown Rot**. The disease has been known, in its sclerotium stage, for many years on hundreds of plants. The connection with *Pellicularia* is recent, and the name does not have universal agreement. One strain of the fungus has been called *Sclerotium delphinii* in the North, where the disease is usually designated crown rot. This is, however, a variable fungus with single spore cultures from the *Pellicularia* stage producing sclerotia typical of *Sclerotium delphinii* and of *S. rolfsii*, with intermediate forms. Sclerotia of the southern blight strain are very small, round, tan, about the size, shape, and color of mustard seed, the pathogen being frequently called the mustard-seed fungus.

Southern blight affects almost all plants except field crops like wheat, oats, corn, and sorghum. Fruits and vegetables include Jerusalem artichoke, avocado, bean, beet, carrot, cabbage, cucumber, eggplant, endive, lettuce, melon, okra, onion, garlic and shallot, pea, peanut, pepper, potato, rhubarb, strawberry, sweetpotato, tomato, turnip, and watermelon. Ornamentals, too numerous to list in entirety, include ajuga, ageratum, amaryllis, azalea, caladium, calendula, campanula, canna, carnation, cosmos, China aster, chrysanthemum, dahlia, delphinium, daphne, duranta, gladiolus, hollyhock, hydrangea, iris, jasmine, lemon verbena, lily, lupine, marigold, morning-glory, myrtle, narcissus, orchids, phlox, pittosporum, rose, rose-mallow, rudbeckia, scabiosa, sedum, sweet pea, star-of-bethlehem, tulip, violet, and zinnia.

The first sign of blight is the formation of white wefts of mycelium at the base of the stem, spreading up in somewhat fan-shaped fashion and sometimes spreading out over the ground in wet weather. The sclerotia formed in the wefts are first white, later reddish tan or light brown. They may be numerous enough to form a crust over the soil for several inches around a stem, or they may be somewhat sparse and scattered.

In the white stage, droplets of liquid often form on the sclerotia, and the oxalic acid in this liquid is assumed to kill plant cells in advance of the fungus hyphae. This means that the pathogen never has to penetrate living tissue and explains why so many different kinds of plants succumb so readily to southern blight. Fruits touching the ground, as well as vegetables with fleshy roots, like carrots and beets, or plants with bulbs or rhizomes, like onions, narcissus, and iris, seem particularly subject to this disease. Low ornamentals such as ajuga blight quickly, the whole plant turning black; tall plants like delphinium rot at the crown and then die back or topple over; bulbs have a cheesy interior, with sclerotia forming on or between the scales.

Control. Remove diseased plants as soon as they are noticed. Take out surrounding soil, for 6 inches beyond the diseased area, wrapping it carefully so that none of the sclerotia drop back. Increasing the organic content of the soil reduces southern blight, as does the addition of nitrogenous fertilizers, such as ammonium nitrate. Treating narcissus bulbs in hot water for 3 hours, as for nematodes, kills the fungus in all except the very largest bulbs.

Pellicularia koleroga (*Corticium stevensii*). **Thread Blight**, a southern disease, from North Carolina to Texas, important on fig and tung, sometimes defoliating pittosporum, crape myrtle, roses, and other ornamentals, and some fruits. The disease is recorded on apple, azalea, banana shrub, blackberry, boxwood, camphor, cherry laurel, chinaberry, columbine, crabapple, crape myrtle, casuarina, currant, dewberry, dogwood, elderberry, elm, erythrina, euonymus, fig, flowering almond, flowering quince, goldenrod, gooseberry, guava, honeysuckle, hibiscus, morning glory, pear, pecan, pepper vine, persimmon, pittosporum, plum, pomegranate, quince, rose, satsuma orange, soapberry, silver maple, sweetpotato, tievine (*Jacquemontia*), tung, Virginia creeper, and viburnum.

The fungus winters as sclerotia on twigs and leaf petioles, and in May and June produces threadlike mycelium that grows over lower surface of leaves, killing them and causing premature defoliation, although often dead leaves hang on the tree in groups, matted together by thread-like spider webs. Fruiting patches on leaves are first white, then buff. The fungus flourishes in moist weather, temperatures 75° to 90°F.

Control. On figs, one or two applications of tribasic copper sulfate, or bordeaux mixture, are satisfactory until the fruit ripens in July. Pruning out infected branches may be sufficient on tung and pecan, but at least one spray of bordeaux mixture may be required.

Thanatephonus cucumeris (formerly *Pellicularia filamentosa*), teleomorph state of *Rhizoctonia solani*. This is a variable fungus with some strains or forms causing leaf blights but best known as cause of Rhizoctonia rot of potatoes and damping-off of many plants. ►Rots.

Thanatephonus cucumeris (formerly *Pellicularia filamentosa* f. sp. *microsclerotia* (*Corticium microsclerotia*)). **Web Blight** of snap bean, lima bean, also reported on fig, elder, hibiscus, hollyhock, tung oil, and phoenix tree, from Florida to Texas. Many small brown sclerotia and abundant weblike mycelium are found on bean stems, pods, and foliage. Infection starts with small circular spots that appear water-soaked or scalded. They enlarge to an inch or more, become tan with a darker border, are sometimes zonate. The whitish mycelium grows rapidly over the leaf blade, killing it, and spreads a web from leaf to leaf, over petioles, flowers, and fruit, in wet weather and at temperatures 70° to 90°F; in dry weather growth is inconspicuous except on fallen leaves. The fungus is spread by wind, rain, irrigation water, cultivating tools, and bean pickers; it survives in sclerotial form from season to season.

Control. Destroy infected plants; clean up refuse. In Florida, do not plant beans between June and September if web blight has been present. Use a copper spray or dust.

Thanatephonus cucumeris (formerly *Pellicularia filamentosa* f. sp. *sasakii*). **Leaf Blight** of grasses, clover, etc.

Thanatephorus cucumeris (formerly *Pellicularia filamentosa* f. sp. *timsii*). **Leaf Blight** of fig.

Penicillium

► Cankers.

Penicillium oxalicum. **Leaf Blight** of grass.

Pestalotia

Deuteromycetes, Coelomycetes

Acervuli dark, discoid or cushion-shaped, subcutaneous; conidiophores short, simple; conidia fusiform, several-celled with median cells colored, end cells hyaline, a short stalk at the basal cells and a crest of two or more hyaline appendages, setae, from the apical cell (Fig. 3.9). Weak parasites or saprophytes; some are treated under Leaf Spots.

Pestalotia funerea (see *Pestalotiopsis funerea*). **Tip Blight** of conifers, **Needle Blight**, **Twig Blight** of chamaecyparis, retinospora, cypress, bald cypress, arborvitae, juniper, yew, and giant sequoia.
Pestalotia hartigii. Associated with a basal stem girdle of young conifers but parasitism not proven. The stem has a swelling above the girdling lesions, and the tree gradually turns yellow and dies. The effect may be more from high temperature than the fungus; shading transplants is helpful.
Pestalotia sp. and **Penicillium** sp. **Flower Blight** on camellia.
Pestalotiopsis funerea (formerly *Pestalotia funerea*). **Tip Blight** of conifers, **Needle Blight**, **Twig Blight** of chamaecyparis, retinospora, cypress, bald cypress, arborvitae, juniper, yew, and giant sequoia. The fungus is saprophytic on dead and dying tissue and also weakly parasitic, infecting living tissue through wounds under moist conditions. It appears in sooty pustules on leaves, bark, and cones.

Phacidium

Ascomycetes, Helotiales

Apothecia innate, concrete above with the epidermis and slitting with it into lobes; spores one-celled, hyaline.

Phacidium abietinellum (see *Nothophacidium abietinellum*). **Needle Blight** of balsam fir.

Phacidium balsameae (see *Sarcotrochilia balsameae*). **Needle Blight** of balsam fir in New England, of white and alpine fir in the Northwest.

Phacidium infestans. **Snow Blight** of conifer seedlings on fir and young pines in the Northeast, also on arborvitae and spruce; on white and alpine fir in the Northwest. This native fungus is most damaging in nurseries, attacking foliage under the snow. The needles turn brown, with a covering of white mycelium, just as the snow melts. In late summer and fall brown to nearly black apothecia appear on underside of browned needles. Ascospores are spread by wind, primary infection being in autumn. Additional infection occurs in late winter, when mycelium grows out under the snow from diseased to dormant, healthy needles.

Control. Spray nursery beds with dormant-strength lime sulfur in late fall; remove infected seedlings; dip new stock in lime sulfur before planting.

Nothophacidium abietinellum (formerly *Phacidium abietinellum*). **Needle Blight** of balsam fir.

Sarcotrochilia balsameae (formerly *Phacidium balsameae*). **Needle Blight** of balsam fir in New England, of white and alpine fir in the Northwest.

Phaeoacremonium

Phaeoacremonium chlamydosporum. **Black Goo** on grape.

Phialophora

► Rots.

Phialophora graminicola. **Blight** on turfgrasses (associated with Fusarium blight syndrome).

Phloeospora

Deuteromycetes, Coelomycetes

Pycnidia dark,imperfectly formed, globose, innate in tissue, not in distinct spots; conidia hyaline or subhyaline, several-celled, elongate fusoid to filiform; parasitic or saprophytic. One of the conidial forms linked with *Mycosphaerella* as a teleomorph state.

Phloeospora adusta. **Leaf Blight** of clematis.

Phoma

► Blackleg.

Phoma conidiogena (see *Phoma glomerata*). **Boxwood Tip Blight**. Ashy gray necrotic areas at leaf tips, with pycnidia on both leaf surfaces.
Phoma glomerata (formerly *Phoma conidiogena*). **Boxwood Tip Blight**. Ashy gray necrotic areas at leaf tips, with pycnidia on both leaf surfaces.
Phoma fumosa. **Twig Blight**, occasional on maple.
Phoma macdonaldii. **Blight**, **Premature Ripening** of sunflower.
Phoma mariae. **Twig Blight** on Japanese honeysuckle.
Phoma piceina. **Twig and Needle Blight** of Norway spruce. May cause defoliation and sometimes death of forest trees.
Phoma sclerotioides. **Brown Root Rot** of alfalfa.
Phoma strobiligena (see *Sclerophoma pythiophila*), on cone scales of Norway spruce.
Sclerophoma pythiophila (formerly *Phoma strobiligena*), on cone scales of Norway spruce.

Phomopsis

Deuteromycetes, Coelomycetes

Pycnidia dark, ostiolate, immersed, erumpent, nearly globose; conidiophores simple; conidia hyaline, one-celled, of two types-ovate or ellipsoidal and long, filamentous, sickle-shaped or hooked at upper end (Fig. 3.9). Anamorph state of *Diaporthe*; parasitic causing spots on various plant parts.

Dendrophoma obscurans (see *Phomopsis obscurans*). **Strawberry Leaf Blight**, **Angular Leaf Spot**.
Phomopsis ambigua (teleomorph, *Diaporthe eres*). **Twig Blight** of pear, widespread.
Phomopsis diospyri. **Twig Blight** of native persimmon.
Phomopsis japonica. **Twig Blight** of kerria.
Phomopsis juniperovora. **Nursery Blight**, **Juniper Blight**, **Cedar Blight**, **Canker** on red-cedar and other junipers, cypress, chamaecyparis, Japanese yew (*Cephalotaxus*), arborvitae, giant sequoia, and redwood. This disease occurs in virulent form from New England to Florida and through the Middle West; it may also occur on the Pacific Coast.

Tips of branches turn brown with progressive dying back until a whole branch or even a young tree is killed. Trees over 5 years old are less seriously injured. Spores produced in quantity in pycnidia on diseased twigs ooze out in little tendrils in moist weather, to be spread by splashing water, insects, and workers. Entrance is through unbroken tissue as well as wounds; the stem is killed above and below the point of entrance. Small, sunken lesions give a flattened appearance to some seedlings. Overhead irrigation in a nursery is a predisposing factor, and a large amount of stock can be blighted in a very short time. Older trees in home plantings suffer from twig blight. The fungus winters on infected plant parts and remains viable at least 2 years.

Control. Have seedbeds well drained; water by ditch irrigation; remove and burn diseased seedlings early in the season; keep seedbeds away from older cedar trees; do not use cedar branches or needles for mulching. Spray with fixed copper or bordeaux mixture plus a wetting agent, starting when growth begins and repeating to keep new foliage covered. Spiny Greek and Hill junipers and Keteller red-cedars are somewhat resistant.

Phomopsis kalmiae. **Mountain-Laurel Leaf Blight**, **Blotch**. Circular, brown, often zonate areas on leaves, frequently starting near margin or tip, gradually enlarge and coalesce until most of the blade is involved. The fungus often works down the petiole to cause a twig blight. The disease is more prominent on bushes in the shade or under drip of trees. Remove blighted leaves or clean up fallen leaves.

Phomopsis longicolla. **Black Pod Spot** and **Seed** on cowpea.

Phomopsis oblonga. **Twig Blight** on Chinese elm.

Phomopsis obscurans (formerly *Dendrophoma obscurans*). **Strawberry Leaf Blight**, **Angular Leaf Spot**. The lesions are large, circular to angular, reddish purple, zonate with age, having a dark brown center, a light brown zone, and a purple border. Spots may extend in a V-shaped area from a large vein to edge of the leaf, with black fruiting bodies appearing in the central portion. Not serious before midsummer, the disease may be destructive late in the season. The fungus winters on old leaves.

Phomopsis occulta. **Shoot Blight** of Colorado blue spruce.

Phomopsis vexans. **Phomopsis Blight** of eggplant. ► *Diaporthe vexans*.

Phomopsis vaccinii. **Twig Blight** of blueberry.

Phyllosticta

Deuteromycetes, Coelomycetes

Pycnidia dark, with ostiole, in spots in leaves; spores one-celled, hyaline. The characteristics are the same as *Phoma* except that leaves rather than stems are infected. Other species are listed under Leaf Spots.

Phyllosticta batatas. **Sweet Potato Leaf Blight**, occasional from New Jersey to Florida, more prevalent in the South but seldom important enough for control measures. Numerous white spots on leaves are bordered with narrow reddish zones; pycnidia are numerous; spores are extruded in tendrils.
Phyllosticta cryptomeriae. **Needle Blight** found on *Cryptomeria*.
Phyllosticta lagerstroemiae. **Tip Blight** of crape-myrtle.
Phyllosticta multicorniculata. **Needle Blight** of fir.
Phyllosticta pteridis. **Tip Blight** of fern. Leaves lose green color; spots are ash gray with purple brown margins and numerous black pycnidia in center. A very weak bordeaux mixture has been suggested for control; if overhead watering is avoided, spraying may not be necessary.

Physalospora

Ascomycetes, Sphaeriales

Perithecia with papillate mouths, immerse in substratum but without well-defined stromata; paraphyses present; spores one-celled, hyaline. A few species cause blights; many cause rots.

Botryosphaeria obtusa (formerly *Physalospora obtusa*). **Cane Blight** of rose, also **Black Rot** of apple, **Canker** and **Dieback** of many plants. ► Cankers and also ► Rots.
Glomerella cingulata (formerly *Physalospora dracaenae*). **Dracaena Tip Blight**, **Leaf Spot**. Disease starts at the tips of lower leaves and spreads down toward the base. Infected areas are sunken and straw-colored, dotted with black specks of pycnidia. All leaves on the plant may die except a few at the top. Remove infected leaves as soon as noticed. Spray with a copper fungicide.
Physalospora dracaenae (► *Glomerella cingulata*). **Dracaena Tip Blight**, **Leaf Spot**.
Physalospora gregaria. **Twig Blight** of yew.

Physalospora obtusa (see *Botryosphaeria obtusa*). **Cane Blight** of rose, also **Black Rot** of apple, **Canker** and **Dieback** of many plants.

Phytophthora

Oomycetes, Peronosporales

This most important genus contains many species causing destructive blights, cankers, and rots. The name, which means "plant destroyer," was given in 1876 for the potato blight fungus. Sporangia, formed successively on sporangiophores, slender, sparsely branched hyphae emerging from stomata, germinate either by a germ tube or by zoospores. The sexual spore is an oospore.

Phytophthora cactorum. **Lilac Shoot Blight**. Blossoms and succulent growing tips are blighted and turn brown; suckers are killed back 4 or 5 feet. Blight is most severe in wet springs when shrubs are crowded, shaded, and improperly pruned. The same fungus causes a canker, foot rot, and dieback of rhododendron and other plants and is considered again under Cankers. Avoid planting lilacs and rhododendrons close together. Prune each year for air circulation and to remove dead twigs.

Phytophthora capsici. **Phytophthora Blight** of Pepper, **Leaf and Stem Blight** of Squash, Fruit Rot of pepper, eggplant, tomato, cucumber, and melon. The disease was first found in New Mexico in 1918 injuring chili peppers; it occurs chiefly in southwestern and Gulf states. In 1953, however, it was reported that for some years it had been causing a leaf blight of squash in North Carolina.

Pepper plants are girdled at the soil line with a dark green water-soaked band, which dries and turns brown, followed by wilting and death of the entire plant. Leaf spots are dark green and small at first, later large bleached or scalded areas. Dark, watersoaked patches on fruits are covered with white mycelium. The fruit withers but remains attached; 60% of green fruit may be infected in southwestern commercial plantings. Seed are infected from the fruit. Symptoms on squash are somewhat similar; green leaf lesions spreading over the blade, a basal stem rot, and wilting. Wet soil and high temperatures encourage blight.

Control. Place seedbeds on land that has not previously grown peppers; rotate crops. Avoid over irrigation.

Phytophthora citrophthora (also *P. citricola* and *P. nicotianae* var. *parasitica*). **Shoot and Stem Blight** on azalea. **Needle Blight** and **Branch Dieback** of sequoia.

Phytophthora erythroseptica. **Leaf Blight** of pink and golden calla. Leaves are wilted and distorted; petioles are black and soft.

Phytophthora ilicis. **Holly Blight**, **Phytophthora Leaf** and **Twig Blight**, the most serious disease of English holly, particularly serious in the Northwest. For many years the trouble was ascribed to *Boydia insculpta* and called Boydia canker, but this fungus merely invades tissue killed by *Phytophthora*. Leaf spots are dark, developing on lower leaves in cool rainy weather and progressing upward in late fall and winter. Young twigs die back; black stem cankers kill older twigs. Young plants in nurseries are defoliated and sometimes killed.

Control. Choose a planting site with moderate air movement; space trees well apart. Prune out all cankered and blighted twigs; prune also for air movement through trees. Spray with tribasic copper sulfate, starting the middle of October.

Phytophthora infestans. **Late Blight** of potato and tomato, general on potato in the Northeast, in Middle Atlantic and North Central states, sometimes in Gulf and western states; on tomato in humid regions and seasons.

Here is a pathogen that has not lost its destructive virulence with passage of time. In 1946, a whole century after potato blight caused the famous Irish famine, tomato blight devastated tomatoes along the eastern seaboard, both in home gardens and canning fields.

The potato went to Europe from South America shortly before 1600, seemingly leaving its pathogens at home. For 200 years potatoes thrived in Europe as the main source of carbohydrate food, but in August 1845, the *Gardener's Chronicle* reported: "A fatal malady has broken out amongst the potato crop. On all sides we hear of destruction. In Belgium the fields are said to have been completely desolated. There is hardly a sound sample in Covent Garden Market." The editor went on to describe the decay and to say: "As to cure for this distemper there is none. One of our correspondents is today angry with us for not telling the public how to stop it; but he ought to consider that Man has no power to arrest the dispensations of Providence. We are visited by a great calamity which we must bear." And in 1946 American gardeners were again blaming the editor, for lack of information on tomato blight.

In 1845 the weather was continued gloom and fog, with below-average temperatures. The *Gardener's Chronicle* editor was sure blight was due to potatoes being overladen with water. The Rev. M. J. Berkeley disagreed. He insisted blight was due to a fungus, with the weather contributing to spread of a moisture-loving parasite. The argument raged, for this was long before Pasteur and his germ theory, and the first time anyone believed a fungus could be the cause and not the consequence of plant disease. A French scientist, Montagne, named the fungus *Botrytis infestans*, but the first really good description of it was published by Berkeley, and it remained for the German de Bary, in 1876, actually to prove the pathogenic nature of the fungus and to erect the new genus *Phytophthora* to include it.

Meanwhile the disease was making history. The loss of the potato crop in 1845 and 1846 killed off a million people and caused another million and a half to emigrate; the first Government Relief program was instigated; and the English Corn Laws were repealed with a change to a policy of free trade and unbounded expansion of commerce.

Late Blight of Potato

Symptoms. After blossoming, large, dark green, water-soaked spots appear on leaves in wet weather, first on lower leaves. As a spot enlarges the center is shriveled, dry, dark brown to black, and a downy, whitish growth appears on the underside of leaves. Similar lesions are formed on stems and petioles, and there is a characteristic strong odor as tops are blighted. On tubers, first symptoms are small brown to purple discolorations of skin on upper side, changing to depressed pits when tubers are removed from soil and put in storage (see Fig. 3.12). On cutting through the potato, a reddish brown dry rot is seen.

Life History. The primary cycle starts with infected tubers, which have harbored mycelium in the dry rot patches over winter. If infected seed pieces are planted, the fungus grows systemically into the shoots and finally fruits by sending sporangiophores out through the stomata on lower leaf surfaces (see Fig. 3.13). These swell at the tips into ovoid bodies, sporangia, then branch and produce successively more sporangia. The latter may function as conidia, putting out a germ tube, but more often are differentiated into a number of swarmspores (zoospores), which have cilia enabling them to swim about after they are splashed by rain to another leaf. Eventually they stop swimming and send a germ tube in through the leaf cuticle or enter through a stoma. Initial infection in the field also comes from conidia blown over from sprouts produced on infected tubers in cull piles. Blighting follows rapidly, with first symptoms 5 days or less from the time of infection

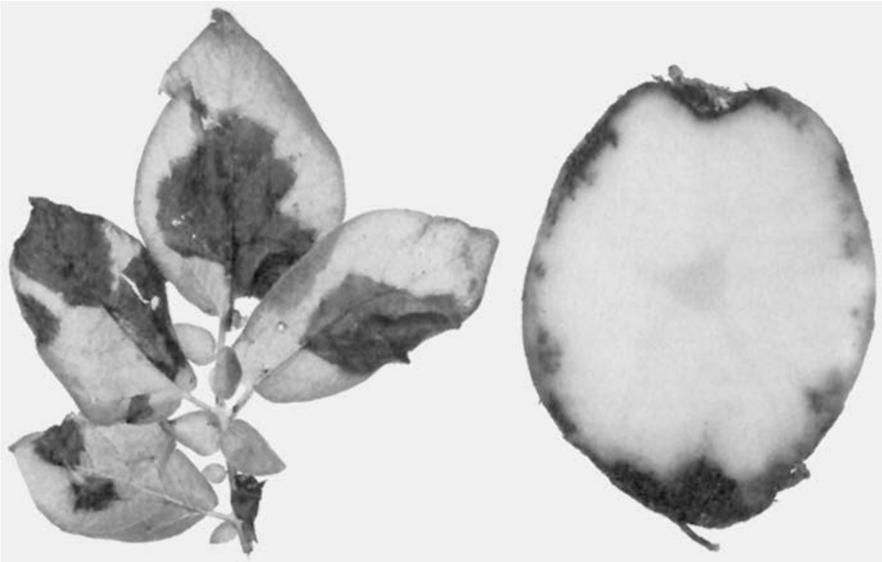


Figure 3.12 Late Blight on Potato

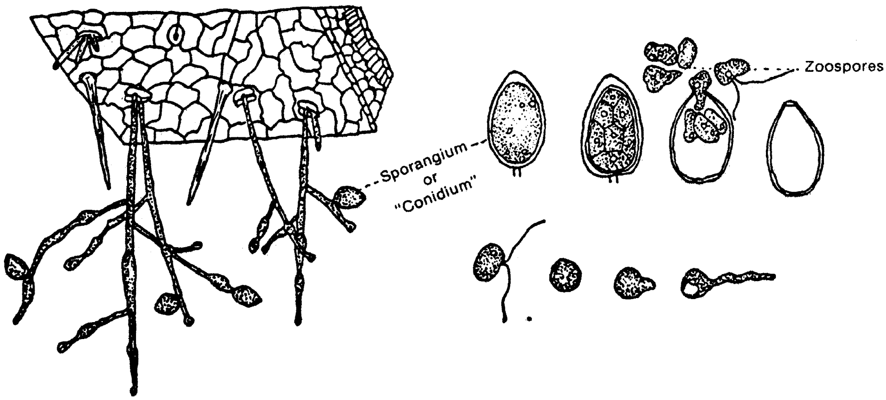


Figure 3.13 Late Blight of Potatoes. Sporangiophores of *Phytophthora infestans* emerging from leaf, bearing sporangia, sometimes called conidia, which germinate by zoospores

and with the fungus fruiting again in a whitish layer on the underside of leaves.

Tubers with only a thin covering of soil may be infected by swarmspores washing down onto them from blighted leaves overhead; they are also infected during digging if it is done in moist weather while tops are still green.

Swarmspores remain viable in the soil several weeks while awaiting favorable conditions. Oospores, the sexual spores, are apparently not required in the life cycle for they are not found with potatoes grown in the field. They have been produced in culture.

Weather Relations. This is a disease entirely dependent on weather conditions. Temperature and moisture conditions are right for an epiphytotic about 2 years out of 5. Zoospores are produced only in cool weather, 60°F and under, but they invade leaves most rapidly at higher temperatures. Because they are swimming spores, rain is required. A cool, wet July is usually followed by blight in August and September.

Control. Some varieties, such as Kennebec, Essex, Pungo, and Cherokee, are resistant to the common strain of the fungus but not to some of the newer strains. Treat potato dumps and cull piles with a weed spray to control sprouts. Delay digging crop until 2 weeks after tops die, or else kill the tops with a weed killer to prevent infection at early digging.

Late Blight of Tomato

Although there are potato and tomato strains of *Phytophthora infestans*, each is capable of infecting the other host. Ordinarily blight starts with potatoes in midsummer; when the fungus moves over to tomatoes, it has to go through several cycles to build up a strain virulent enough to produce general blighting, and by that time the tomato season is nearly over. Now we know that it is possible for the tomato strain to winter in potato tubers and be ready to inflict damage on tomatoes with the first crop of zoospores produced on potato sprouts. Conversely, tomato seedlings brought up from the South and planted near potato fields can start an epiphytotic of late blight on potatoes.

The 1946 tomato blight saga – the one that awakened eastern gardeners to the fact that plant disease could be as important to home gardeners as to farmers – started in Florida late in November 1945. By January the disease was extremely destructive in tomato seedbeds, and it continued so intermittently whenever temperatures ranged from 60° to 70°F and relative humidity was nearly 100% for more than 15 hours. Evidence indicated spores could be wind-borne for as far as 30 miles. The wave of late blight went west to Alabama, taking 75% of the early crop, and rolled up the Atlantic

Figure 3.14 Late Blight on Tomato

Coast, reaching the Carolinas in May and Virginia and Maryland in June, again taking 75% of the early crop. It rolled into Delaware and New Jersey in July, but did not reach peak epidemic form until after an extended rainy period in August, and ended in Massachusetts in August and September.

In 1947 a blight-forecasting service was started, based on weekly graphs prepared by plotting daily the cumulative rainfall and mean temperatures and aided by reports from key pathologists in various states. If conditions are unfavorable for blight, we can save time and money by eliminating useless spraying.

Symptoms. On seedlings small, dark spots on stems or leaves are followed by death within 2 or 3 days. On mature plants blight starts with dark, water-soaked leaf spots and large, dark brown spots on fruit, with most of the leaves soon hanging lifeless and fruit rotting on the ground (see Fig. 3.14).

Control. Bordeaux mixture applied to young tomato plants will either prevent fruit setting or cause stunting. It can be used after blossoming, or a fixed copper can be substituted.

Phytophthora meadii. **Blight** and **Leaf Spots** on West Indian holly.

Phytophthora medicaginis. **Rot Root** on Medicago spp.

Phytophthora nicotianae (formerly *Phytophthora parasitica* var, *parasitica*. **Leaf, Stem and Bub Blight** on bougainvillea, dogwood, hibiscus, artillery plant, and aluminum plant. Leaf blight; on jojoba.

Phytophthora parasitica var. parasitica (see *Phytophthora nicotianae*). **Leaf, Stem and Bub Blight** on bougainvillea, dogwood, hibiscus, artillery plant, and aluminum plant. Leaf blight; on jojoba.

Phytophthora syringae. **Citrus Blight**, also on lilac, but the more common lilac blight is due to *P. cactorum*. On citrus trees leaves have semitransparent spots similar to frost damage. Other *Phytophthora* species may be present with *P. syringae* to cause brown rot of fruits. ►Rots. On lilacs large irregular leaf patches have a lighter zone at margin. There may be some defoliation.

Plectosporium

Plectosporium abacinum. **Blight** on Hydrilla.

Pyrenochaeta

Deuteromycetes, Sphaeropsidales, Sphaerioidaceae

Pycnidia dark, ostiolate, nearly globose, erumpent with a few bristles near ostiole; conidiophores simple or branched; conidia small, one-celled, hyaline, ovate to elongate; parasitic or saprophytic. See also under Rots.

Pyrenochaeta phlogis. **Stem Blight** of Phlox.

Pyricularia

Deuteromycetes, Hyphomycetes

Conidiophores long, slender, simple or rarely branched, septate, single or in tufts; conidia pyriform to nearly ellipsoid, borne singly and attached at broader end; spores hyaline, two- to three-celled; parasitic, chiefly on grasses.

Pyricularia grisea. **Leaf Blight** on creeping bent grass and buffelgrass.

Pythium

► Rots.

Pythium myriotylum. **Blight** of tomato.

Delphinella (Rehmiellopsis)

Ascomycetes, Dothideales

Perithecia single, globose, rupturing irregularly; asci in fascicles, no paraphyses; spores hyaline, two-celled.

Delphinella balsameae (formerly *Rehmiellopsis balsameae*). **Tip Blight**, **Needle Blight** of balsam fir, on native balsam fir in northern New England and on ornamental firs in southern New England and New York. Infection is in spring with needles of current season shriveled, curled, and killed, often with a dieback of terminal or lateral shoots and sometimes cankers at base of infected needles. Satisfactory control on ornamental firs has been obtained by three sprays, at 10-day intervals, of bordeaux mixture, the first application made as new growth starts.
Rehmiellopsis balsameae (see *Delphinella balsameae*). **Tip Blight**, **Needle Blight** of balsam fir, on native balsam fir in northern New England and on ornamental firs in southern New England and New York.

Rhizoctonia

Deuteromycetes, Mycelia Sterilia (Fungi Imperfecti)

Sclerotial form of some species of *Pellicularia, Corticium, Macrophomina*, and *Helicobasidium*. Young mycelium colorless, with branches constricted at points of origin from main axis, but soon colored, a weft of brownish yellow to brown strands, organized into dense groups, sclerotia made up of short, irregular, angular or somewhat barrel-shaped cells.

Rhizoctonia ramicola. **Silky Thread Blight** a southern disease similar to web blight caused by *Pellicularia koleroga*. Perennial ornamental hosts in Florida include elaeagnus, erythrina, crape-myrtle, holly, guava, pittosporum, pyracantha, Carolina jessamine, feijoa, and rhododendron. Tan spots with purple-brown margins appear on leaf blades, dead lesions on petioles and young twigs. When leaves are abscissed, they are often held dangling and matted together by brown fungus threads. Infection recurs annually in moist weather with high daytime temperatures. The fungus winters as mycelium in leaf lesions and diseased twigs. Sclerotia are apparently lacking in this species.

Rhizoctonia sp. (teleomorph, *Aquathanatephorus pendulus*). **Blight** on water hyacinth.

Rhizoctonia sp. (teleomorph, *Thanatephorus cucumeris*). **Blight** on beet. **Needle blight** on pine.

Rhizoctonia solani. **Blight** of pistachio and *Cynodon* spp., and **Foliar Blight** of soybean.

Rhizopus

► Rots.

Rhizopus stolonifer. **Seedling Blight** on lupine; also caused by *Pleiochaeta setosa, Alternaria* sp., *Aspergillus flavus, Aspergillus niger*, and *Curvularia* sp.

Rosellinia

Ascomycetes, Xylariales

Perithecia separate, superficial from the first, carbonaceous, not beaked, ostioles papillate; spores dark, one-celled with a small groove.

Rosellinia herpotrichioides. **Hemlock Needle Blight**. Needle-bearing portions of twigs become covered on underside with a grayish brown mycelial mat; black perithecia are produced in this mat in great abundance. Ovoid, hyaline conidia are formed on *Botrytis*-like conidiophores.

Schirrhia

Ascomycetes, Dothideales, Dothideaceae

Asci usually short, cylindrical, and relatively numerous in spherical, ostiolate locules.

Scleropycnium

Deuteromycetes, Coelomycetes

Pycnidia open out to a deep cupulate or discoid structure, tough, dark or black, subepidermal or subcortical, then erumpent; spores hyaline, one-celled. Largely saprophytic on twigs, sometimes parasitic on leaves.

Scleropycnium aureum. **Leaf Blight** of mesquite.

Sclerotinia (Whetzelinia)

Ascomycetes, Helotiales, Sclerotiniaceae

Apothecia arising from a tuberoid sclerotium which, though formed free on aerial mycelium, is sometimes enclosed in natural cavities of suscept or host, as in hollow stem of perennials. Interior (medulla) of sclerotium white, completely enveloped by a dark rind; gelatinous matrix lacking. Conidia wanting but spermatia (very small microconidia) formed on sporodochia borne free or enclosed in cavities. Apothecia some shade of brown; cupulate to funnel-form; usually at maturity saucer-shaped to flat expanded; ascospores hyaline, one-celled, ovoid. Species formerly included in *Sclerotinia* but possessing monilioid conidia are now in *Monilinia*.

Botryotinia polyblastis (formerly *Sclerotinia polyblastis*). **Narcissus Fire**. A serious flower blight in England, known here on the Pacific Coast. In England overwintering sclerotia produce apothecia when *Narcissus tazetta* comes into flower, the ascospores infecting the perianth and causing flower spotting. From withered flowers numerous large conidia, germinating with several germ tubes, infect foliage, on which large sclerotia are formed late in the season. Remove infected parts immediately; spray early in the season.

Ciberinia camelliae (formerly *Sclerotinia camelliae*). **Camellia Flower Blight**, long known in Japan, first noted in California in 1938, confirmed in Georgia in 1948, although probably there several years previously, reported in Oregon in 1949, Louisiana and North Carolina in 1950, South Carolina in 1954. The blight is now widespread in Virginia, confined to certain counties in other states. It was not officially recorded from Texas until 1957 but must have been there earlier. The 1950 outbreak at Shreveport, Louisiana, is said to have started on plants brought in from Texas that probably originated in California.

Floral parts only are affected, infection taking place any time after tips of petals are visible in opening buds. Few to many brownish specks on expanding petals enlarge until the whole flower turns brown and drops. In early stages darkened veins are prominent diagnostic symptoms. When the flowers rest on moist earth, spermatia are produced on petals in shiny black masses. Hard, dark brown to black sclerotia formed at the base of petals frequently unite into a compound structure simulating petal arrangement. This compound sclerotium may be an inch or more in diameter. Although the petals do not melt when touched as do azaleas with petal blight, there is a distinctive moist feeling that helps to differentiate flower blight from frost injury. Rarely, a flower blight of camellias is caused by another *Sclerotinia* (*S. sclerotiorum*).

Sclerotia lie dormant on ground or in mulching materials until the next winter when, from January on (possibly earlier), after wet periods with rising temperature, they produce one to several apothecia on long or short stipes with brown, saucerlike discs 1/4 to 3/4 inch across, rarely up to 1 inch. Spores, discharged forcibly, are carried by wind currents to flowers, thus completing the cycle. Spores may be wind-borne at least 1/3 mile, but presumably a large proportion of them land on opening petals of the bush overhead. The sclerotia remain viable in the soil at least 2 or 3 years, sending up more apothecia each season. No conidia are known; so there is no secondary infection from flower to flower as with azalea blight. The amount of primary inoculum is very large, however. One afternoon in New Orleans I collected nearly 1000 sclerotia that were producing apothecia from under a single camellia.

Control. The first line of defense is exclusion. Most southern states have quarantines against known infected areas; they require that plants be shipped bare-rooted, with all flower buds showing color removed. Northern gardeners ordering plants for greenhouses should insist on the same precautions even without specific quarantines. Practically all outbreaks of camellia flower blight have been traced to plants shipped in cans, presumably carrying sclerotia in the soil. The disease has also appeared on flowers shipped in by air for camellia shows. Schedules should state that all specimens become the property of the show committee, to be destroyed at the end of the show; no blooms should be taken home for propagation.

Theoretically, because there is no conidial stage to spread the fungus, this should be an easy disease to eradicate, but it has not proved so in practice. Camellias have thousands of flowers produced over a period of months.

They drop into various ground covers, and it is almost impossible to find and destroy all infected blooms before rotting tissues release sclerotia into the litter. Some cities have quarantined infected properties and provided a host-free period of 2 years, during which all flower buds are removed from all camellias in the area, but this approach has been only partially successful. Various chemicals have been tried as ground treatment to inhibit formation of apothecia.

Sclerotinia camelliae (see *Ciberinia camelliae*). **Camellia Flower Blight**, long known in Japan, first noted in California in 1938, confirmed in Georgia in 1948, although probably there several years previously, reported in Oregon in 1949, Louisiana and North Carolina in 1950, South Carolina in 1954.

Sclerotinia minor. **Blight** of soybean, peanut, and Eclipta.

Sclerotinia (*Botryotinia*) **polyblastis** (see *Botryotinia polyblastis*). **Narcissus Fire**. A serious flower blight in England, known here on the Pacific Coast. **Sclerotinia rolfsii**. **Southern Blight** on St. Johnswort.

Sclerotinia sclerotiorum. **Shoot and Twig Blight** of lilac, grape, pistachio, soybean, peanut, and malaviscus; flower blight of camellia resembling that caused by *S. camelliae* but far less serious. Tuber blight and storage rot; of Trillium. This ubiquitous fungus more often causes stem rots on its many different hosts. ►Rots.

Sclerotium

Deuteromycetes, Mycelia Sterilia (Fungi Imperfecti)

AsexuaI fruit bodies and spores lacking; there is merely a resting body, sclerotium, made up of a compact, rounded mass of light-colored hyphae with a brown to black rind; parasitic, often on underground plant parts. *Pellicularia* has proved to be the teleomorph state for some forms.

Sclerotium bataticola. **Ashy Stem Blight**. See *Macrophomina phaseoli* under Rots.

Sclerotium hydrophilum Blight of wild rice.

Sclerotium oryzae. **Blight** of wild rice.

Sclerotium rhizodes. **White Tip Blight** of grass. ►Snowmold.

Sclerotium rolfsii. **Southern Blight**. ►*Pellicularia rolfsii.*

Septoria

Deuteromycetes, Coelomycetes

Pycnidia dark, separate, globose, ostiolate; produce in spots, erumpent; conidiophores short, conidia hyaline, narrowly elongate to filiform, several septate; parasitic, typically causing leaf spots, but also blights and blotches (see Fig. 3.9). There are about 1000 species.

Septoria apiicola (**Syn. Septoria apii** and **S. apii-graveolentis**). **Celery Late Blight**, general on celery, also on celeriac. The two species, singly or together, produce the disease known as late blight, first reported in Delaware in 1891 and since causing much crop destruction, one California county reporting half a million dollars loss from celery blight in 1908 and Michigan a million in 1915. It was not known until 1932 that two distinct species were involved.

Early symptoms are similar. Large leaf spot, due to *S. apii*, starts as a light yellow area, which soon turns brown and dies. Spots are up to 1/4 inch in diameter, with small black pycnidia. In small leaf spot, due to *S. apii-graveolentis*, the more common and destructive pathogen, pycnidia appear at the first sign of chlorotic spotting and are often outside of the indefinite margins of the spots, which are not over 2 mm. If infection is severe, the spots fuse, and the leaves turn brownish black and rot. Leaf stalks may also be infected. Pycnidia winter on seed and in plant refuse in garden and compost. A single pycnidium of the small-spot fungus has an average of 3675 spores, extruded in gelatinous tendrils. A single leaf spot may average 56 pycnidia, and a single plant may have 2000 spots. Thus there are enormous amounts of inoculum to be spread by rain, insects, people, and tools. Some years ago on Long Island, when celery was inter-cropped with spinach, it was found that workers spread blight spores on their sleeves as they cut the spinach in early morning dew. And there is a case on record where a man walked through his own blighted celery before taking a diagonal path across his neighbor's healthy field. In a few days blight showed up all along that diagonal path.

Control. The fungus usually dies in the seed coat while the seed is still viable. Using celery seed more than 2 years old obviates the necessity for treatment. Fresh seed can be soaked in hot water for 30 minutes at 118° to 120°F. Use crop rotation; do not plant near where celery was grown the year before. Spray with bordeaux mixture or a fixed copper, starting in the seedbed when plants are just out of the ground.

Septoria leucanthemi*. **Leaf Blight**, **Blotch** on chrysanthemum, shasta daisy, and oxeye daisy. The generally destructive *Septoria* on chrysanthemum is *S. chrysanthemi*. ► Leaf Spots.

Septoria petrosellini. **Leaf Blight** of parsley, similar to late blight of celery but confined to parsley.

*Recent study indicates these are one species and that the name should be *S. apiicola*.

Septotinia

Ascomycetes, Helotiales, Sclerotiniaceae

Stroma a definite, small, thin, elongate to angular black sclerotium maturing in host tissue after it has fallen to ground. Apothecia shallow cup-shaped, stipitate; spores hyaline, ovoid, one-celled. Conidial stage a *Septotis*, with hyaline spores, two or more cells, formed on sporodochia.

Septotinia podophyllina. **Leaf Blight** of may-apple, found on leaves and stalks of this plant only.

Servazziella

Ascomycetes, Amphisphaeriales

Perithecia immersed in a stroma, with long necks converging into a disc; ascospores long, filiform, hyaline; conidia on a stroma.

Cryptospora longispora (see *Servazziella longispora*). **Araucaria Branch Blight**.

Servazziella longispora (formerly *Cryptospora longispora*). **Araucaria Branch Blight**. Lower branches are attacked first, with disease spreading upward; tip ends are bent and then broken off; plants several years old may be killed. Prune off and burn infected branches.

Sirococcus

Deuteromycetes, Sphaeropsidales, Sphaerioidaceae.

Small, rounded, black, semi-immersed pycnidia with wide ostioles; conidia hyaline, fusiform, slightly constricted, 1-septate.

Sirrococcus elavigignenti-juglandacearum. **Canker** of black walnut and butternut.
Sirococcus strobilinus. **Shoot Blight** of *Picea, Abies, Pinus*, and *Tsuga* spp.

Sphaeropsis

► Cankers.

Sphaeropsis sapinea. **Shoot Blight** of pine.

Dothiora (Sphaerulina)

Ascomycetes, Dothideales

Perithecia innate or finally erumpent, not beaked; paraphyses and paraphysoids lacking; spores hyaline, several-celled.

Dothiora wolfii (formerly *Sphaerulina polyspora*). **Twig Blight** of sourwood, and oxydendron.
Dothiora taxicola (formerly *Sphaerulina taxi*). **Needle Blight** of yew.
Sphaerulina polyspora (see *Dothiora wolfii*). **Twig Blight** of sourwood, and oxydendron.
Sphaerulina taxi (see *Dothiora taxicola*). **Needle Blight** of yew.

Sporidesmium

Deuteromycetes, Hyphomycetes

Conidiophores clustered, dark, short, simple, each bearing a terminal conidium; conidia dark, quite large, muriform with many cells, oblong to ovoid; usually saprophytic, sometimes parasitic.

Alternaria scorzonerae (formerly *Sporodesmium scorzonerae*). **Salsify Leaf Blight**. Leaves have many circular ispots, varying from pin point to 1/4 inch, brown with red borders. Leaves or whole tops die; roots are small and unsalable. The fungus winters as mycelium and spores in plant refuse. May be the same as *Alternaria tenuis*.

Sporidesmium maclurae. **Leaf Blight** of osage-orange.

Sporodesmium scorzonerae (see *Alternaria scorzonerae*). **Salsify Leaf Blight**. Leaves have many circular ispots, varying from pin point to 1/4 inch, brown with red borders.

Stemphylium

► Leaf Spots.

Stemphylium vesicarium. **Stemphylium Blight** of onions. Lesions are nondelineated, light yellow to brown, water-soaked and range in length from one centimeter to the entire leaf.

Systremma

Ascomycetes, Dothideales

Asci in locules in an elongated stroma, which is erumpent and superficial at maturity; spores light brown, two-celled. Conidial state *Lecanosticta* with brown conidia, two to four cells, formed on a conidial stroma resembling an acervulus.

Mycosphaerella dearnessii (formerly Systremma acicola). **Pine Brown Spot Needle Blight**, on southern pines, most serious on longleaf. The name and classification of the fungus has been in dispute. The conidial stage, known since 1876, was first listed as *Septoria*, later placed in *Lecanosticta*. The teleomorph state was named *Scirrhia acicola* in 1939 but later transferred to *Systremma* because of its colored spores.

Most injurious on seedlings, needle blight may also injure large trees. Small, gray-green spots on needles turn brown and form a narrow brown band, the needle tips dying. Three successive seasons of brown spot kill longleaf seedlings. The fungus is more severe on trees in unburned areas because of accumulation of inoculum. Spray seedlings in plantations with bordeaux mixture every 2 weeks from May to October or November.

Systremma acicola (see *Mycosphaerella dearnessii*). **Pine Brown Spot Needle Blight**, on southern pines, most serious on longleaf.

Thelephora

Basidiomycetes, Aphyllophorales

Fruiting body leathery, upright, stalked; pileate or fan-shaped or much lobed, or in an overlapping series; hymenium on the underside, smooth or slightly warty; spores one-celled.

Thelephora spiculosa. **Stem Blight** found on azalea, fern, and other ornamentals in a Maryland garden. The fungus formed a dense weft of mycelium on surface of the soil and on plants.

Thelephora terrestris. **Seedling Blight**, **Smother**. The mycelium ramifies in the soil, and the leathery fruiting body grows up around the stem of a seedling conifer or deciduous tree, smothering it or strangling it without being actually parasitic on living tissue. The disease occurs most often in crowded stands in nurseries. The damage is seldom important.

Tryblidiella

Ascomycetes, Patellariales

Apothecia opening by a wide cleft; spores dark, cylindrical, with several cells.

Rhytidhysteron rufulum (formerly *Tryblidiella rufula*). **Twig Blight** on citrus.

Tryblidiella rufula (see *Rhytidhysteron rufulum*). **Twig Blight** on citrus.

Volutella

Deuteromycetes, Hyphomycetes

Sporodochia discoid, with marginal dark setae; conidiophores usually simple, in a compact palisade; conidia hyaline, one-celled, ovoid to oblong; parasitic or saprophytic (see Fig. 3.9).

Pseudonectria pachysandricola (see *Volutella pachysandrae*, Telemorph). **Pachysandra Leaf** and **Stem Blight**. Large areas of leaves turn brown to black, along with portions of stems, and in wet weather numerous pinkish spore pustules appear along stems.

Volutella buxi. **Boxwood Leaf Blight**, **Nectria Canker**. Pinkish spore occur as pustules on leaves and twigs. Leaves often turn straw-colored. See further under Cankers.

Volutella pachysandrae (formerly, *Pseudonectria pachysandricola*). **Pachysandra Leaf** and **Stem Blight**. Large areas of leaves turn brown to black, along with portions of stems, and in wet weather numerous pinkish spore pustules appear along stems. The blight is most serious when pachysandra has been injured or is too crowded or is kept too moist by tree leaves falling into the bed. Spraying once or twice with bordeaux mixture gives excellent control if severely blighted plants have been removed before treatment. Keep pachysandra thinned and sheared back periodically.

BLOTCH DISEASES

Diseases designated as blotch have symptoms that are intermediate between blights, where the entire leaf or shoot dies, and leaf spots, where the necrotic lesions are definitely delimited. Blotches are irregular or indefinite large or small necrotic areas on leaves or fruit.

Alternaria

► Blights.

Alternaria porri. **Purple Blotch** of onion, also on garlic, and shallot, a problem in southern and irrigated areas. Small, white, circular to irregular spots increase to large purplish blotches, sometimes surrounded by orange and yellow bands, on leaves and flower stalks. Leaves often turn yellow and die beyond the spots; girdled stalks die before seeds mature. Brown muriform spores form a dusky layer on the blotches. Varieties with a waxy foliage are more resistant than those with glossy leaves. The fungus winters as mycelium and spores in crop refuse. Rotation, cleaning up plant debris, and seed treatment are recommended.

Two other species of *Alternaria, A. alternata* and *A. tenuissima*, may cause purple or brown blotches on onion, and there are physiological races as well.

Cercospora

► Blights.

Cercospora concors (see *Myrovellosiella concors*). **Potato Leaf Blotch**. An unimportant disease; leaflets turn yellow with small blackened dead areas or larger, irregular brown areas.

Cercospora purpurea (see *Pseudocercospora purpurea*). **Avocado Blotch**, **Cercospora Spot**, considered the most important avocado disease in Florida with no commercial variety entirely resistant.

Myrovellosiella concors (formerly *Cercospora concors*). **Potato Leaf Blotch**. An unimportant disease; leaflets turn yellow with small blackened dead areas or larger, irregular brown areas.

Pseudocercospora purpurea (formerly *Cercospora purpurea*). **Avocado Blotch**, **Cercospora Spot**, considered the most important avocado disease in Florida with no commercial variety entirely resistant. Leaf spots are angular, brown to chocolate brown, scattered and distinct, less than 1/16 inch or coalescing to larger patches. With a hand lens, grayish spore groups can be seen on both sides of the leaf. Successive crops of spores are produced in moist periods throughout the year. Fruit spots are 1/4 inch or less in diameter, brown to dark brown, irregular, sunken, with cracked surfaces and grayish spore tufts. Lesions are confined to the rind so that the flesh is not affected, but the cracks furnish entrance to anthracnose and other decay organisms. The fungus winters in leaves, and appears to be progressively more abundant.

Cladosporium

Deuteromycetes, Hyphomycetes

Conidiophores dark, branched variously near upper or middle portion, clustered or single; conidia dark, one- or two-celled, variable in size and shape, ovoid to cylindrical, borne singly or in chains of two or three; parasitic or saprophytic.

Cladosporium herbarum. **Leaf Blotch** of lilac. The fungus is usually secondary, saprophytic, following blights.

Cladosporium paeoniae. **Peony Leaf Blotch**, **Red Stem Spot**, **Measles**. Leaf and stem spots are purplish or brownish red. On stems the spots are raised, up to 4 mm long; on leaves the lesions are small specks. Small reddish spots are also present on floral bracts and petals. The disease is widely distributed in commercial plantings and may sometimes destroy the value of flowers for cutting. Cut down tops in fall as for Botrytis blight. Spraying the ground with Elgetol in spring before new growth starts has given good control in some fields.

Geastrumia

Geastrumia polystigmatis. **Sooty Blotch of Fruit** on apple and blackberry.

Gloeodes

Deuteromycetes, Sphaeropsidales, Leptostromataceae

Pycnidia dimidiate, having a radiate cover over the top half only, on a dark subicle or mycelial crust; pseudoparaphyses present; conidia hyaline, one-celled.

Gloeodes pomigena. **Sooty Blotch of Fruit** on apple, crabapple, blackberry, pear, and citrus, in eastern and central states down to the Gulf, rare in the West. Fruit may be infected by heavy spore dissemination from pycnidia on twigs of various wild trees, including persimmon, prickly-ash, white ash, bladdernut, hawthorn, red elm, sassafras, maple, sycamore, and willow. On apples, clusters of short dark hyphae make a superficial thallus on the cuticle, which appears as a sooty brown or black blotch, 1/4 inch in diameter. Numerous spots may coalesce to cover the apple, a condition known as cloudy fruit. Because the lesion is superficial the fruit flesh is little affected, but the grade and market value are reduced. On citrus the fungus does not penetrate the rind, and spots can be removed by gentle hand rubbing. The disease develops in cool rainy weather during the summer. To control open up the trees in the orchards to facilitate quick drying.

Guignardia

Ascomycetes, Dothideales

Perithecia immersed in substratum, stroma lacking, mouths papillate; spores hyaline unequally two-celled, with lower cell cut off just before maturity.

Guignardia aesculi. **Horse-Chestnut Leaf Blotch**, **Buckeye Leaf Blotch**, general on horse-chestnut and Ohio buckeye, sometimes on red and yellow buckeye. Large, reddish brown blotches in foliage are, usually, surrounded by a yellowish area. Numerous pin-point black dots, pycnidia, distinguish blotch from scorch due to drought. Petioles often have reddish oval spots. In a rainy season there is a good deal of secondary infection from spores spread by wind and rain. Blotches appear on nearly every leaflet with extensive defoliation. Primary infection in spring comes from ascospores developed in fallen overwinter leaves.
Control. Rake up and burn leaves in fall. Feed trees that have been defoliated for successive years.

Mycosphaerella

► Blights.

Mycosphaerella dendroides (*Cercospora halstedii*, Anamorph). **Pecan Leaf Blotch**, on pecan in the South, on hickory in East and South, a foliage disease of nursery and orchard trees. Olive green velvety tufts of conidiophores and spores appear on undersurface of mature leaves in June and July (in Florida), and yellow spots appear in corresponding areas on upper leaf surfaces. Black pimplelike perithecia are produced in the tufts about midsummer, united in groups to give the leaf a shiny black, blotched appearance after the spores are washed away. In nursery trees, defoliation, starting with basal leaves and progressing upward, may be serious. The disease is of little consequence to orchard trees unless they have been weakened by overcrowding, borer attack, or other cause. The fungus winters in fallen leaves. To control clean up fallen leaves.

Mycosphaerella diospyri. **Leaf Blotch** of Japanese persimmon.

Mycosphaerella lythracearum (*Cercospora punicae*, Anamorph). **Leaf Blotch**, **Fruit Spot** of pomegranate. The anamorph state has been thought the same as that on crape-myrtle (*Cercospora lythracearum*), but is now considered distinct. Leaf spots are circular, small, dark reddish brown to almost black, sometimes grayish brown.

Phoma

► Blackleg.

Phoma arachidicola. **Web Blotch** of peanut.

Phyllosticta

► Blights.

Phyllosticta congesta. **Leaf Blotch** of garden plum.

Phyllosticta solitaria. **Apple Blotch**, widespread on apple and crabapple in eastern states, serious in the South and in the Ozark section of Missouri, Arkansas, Oklahoma, and Texas. The disease is also called fruit blotch, dry rot, black scab, late scab, cancer, and tar blotch. From Kansas eastward it is second in importance to apple scab. Leaf spots are very small, round, white, with a single black pycnidium in the center of each. Larger elongate lesions are formed on veins, midribs, and petioles. Leaves do not turn yellow, but they drop prematurely if spots are numerous. Cankers on twigs and branches are located at leaf nodes or base of spurs. The first season they are small, purple to olive in color; the next season this portion is tan and the new area dark purple, often slightly raised. Pycnidia formed in twig lesions wash to leaves, fruit, and new shoots, discharged only after heavy rains and in warm weather. Heavily fertilized trees are more susceptible.

Fruit blotches are brown, irregular, feathery at the margin, studded with numerous pycnidia. They afford entrance to secondary decay organisms and may develop deep cracks, but the blotch fungus itself is superficial. It winters in infected twigs and bark cankers.

Control. Secure healthy nursery stock. Some varieties, including Grimes Golden, Jonathan, Stayman Winesap, and Winesap, are rather resistant.

Septoria

► Blights.

Septoria agropyrina. **Brown Leaf Blotch** on wheat grasses.

Septoria elymi. **Speckled Leaf Blotch** on wheat grasses. A salt and pepper effect with numerous pycnidia in pale gray, tan, or fuscous lesions.

Septoria macropoda. **Purple Leaf Blotch**, general on blue grasses. Irregular blotches on blades are mottled greenish, then gray, tan or brown, finally bleached nearly white. Pycnidia are round, flattened, and light brown.

Zygophiala

Deuteromycetes, Hyphomycetes

A genus described from banana leaves in Jamaica.

Zygophiala jamaicensis. **Greasy Blotch** of carnation. A tropical fungus found causing serious losses in California greenhouses in 1953 and reported from Pennsylvania in 1957. Small, radiate patterns, resembling spider webs, appear as if dipped in oil. Leaves become brittle, turn yellow, and die prematurely. The same fungus is present as a flyspeck on apple.

BROOMRAPES

Broomrapes are parasitic seed plants like dodder and mistletoe. They are leafless herbs, of the family Orobanchaceae, living on roots of other plants and arising from them in clumps of whitish, yellowish, brownish, or purplish stems. There are 130 or more species, mostly from North Temperate regions, but few have any garden importance. The seed germinates in soil and produces a filiform plant body that grows into the ground penetrating crown or root of the host plant and forming a more or less tuberous enlargement, from which the flowering shoots arise. Such shoots may be nearly naked, clothed only with a few scattered rudimentary leaves, or they may be covered with conspicuous, overlapping scalelike leaves. The seed may remain viable in the soil several years but probably not as long as has been believed, for they can live on some weeds between crops.

Orobanche ludoviciana. **Louisiana Broomrape** on tomato and other plants, including Spanish needle and coldenia, becoming a problem in California. Tomatoes are stunted and do not produce a full crop of fruit.

Orobanche ramosa. **Branched Broomrapeh**, **Hemp Broomrape**, most serious on hemp but parasitizing tomatoes, lettuce, tobacco, eggplant, *Ganra, Melitlotus, Silene*, poppy mallow, cranesbil, *Chaerophyllum, Verbena, Coreopsis*, fleabank, engelmann daisy, and other hosts in California. In small infections destroy the aerial stems before they set seed; practice crop rotation. Deep plowing gives some control.

CANKERS AND DIEBACKS

A canker is a localized lesion or diseased area often resulting in an open wound and usually on a woody structure. Starting as a definite necrotic spot, it may girdle cane, stem, or tree trunk, killing the water-conducting tissues so that the most prominent symptom becomes a dieback. When twigs and branches die back from the tip, the condition may be a blight, with the pathogen directly invading the dying area, or it may be a secondary effect from a canker some distance below.

Aleurodiscus

Basidiomycetes, Aphyllophorales

Hymenium resupinate, of one layer, with projecting spinose or short-branching cystidia (swollen sterile cells); spores hyaline. Facultative parasite on trees.

Aleurodiscus acerina (see *Dendrothele acerina*). **Bark Patch**, widespread on maple.

Aleurodiscus amorphus. **Balsam Fir Canker**. Cankers are formed on main stems of saplings, which are sometimes killed, but the fungus is also widespread as a saprophyte on dead bark of firs and other conifers. Cankers center around a dead branch, are narrowly elliptical with a raised border; the dead bark is covered with a light-colored layer of the fungus.

Aleurodiscus oakesii. **Oak Bark Patch**, **Smooth Patch** of white oak. Irregularly circular, smooth, light gray sunken areas in bark vary from several inches to a foot across. The fungus is confined to dead bark; trees are not injured.

Dendrothele acerina (formerly *Aleurodiscus acerina*). **Bark Patch**, widespread on maple.

Amphobotrys

Deuteromycetes, Hyphomycetes

Conidiophores are long, slender, pigmented, and highly branched; clusters of conidia at apex of each branch; conidia ovoid, one-celled, hyaline.

Amphobotrys ricini. **Stem Canker** on texasweed and castorbean. Girdling stem canker; of prostrate spurge.

Apioporthe

Ascomycetes, Diaporthales

Perithecia in a black, carbonaceous stroma; spores two-celled, hyaline; conidia in cavities in a stroma.

Anisogramma anomala (formerly **Apioporthe anomala**). **Canker**, **Twig Blight** of hazelnut.
Apioporthe anomala (see *Anisogramma anomala*). **Canker**, **Twig Blight** of hazelnut.
Apioporthe apiospora. **Twig Canker**, **Dieback** of elm.

Ascospora

Ascomycetes, Sphaeriales, Sphaeriaceae

Perithecia with a subicle; paraphyses lacking; spores two-celled, hyaline.

Ascospora ruborum (*Hendersonia rubi*, Anamorph). **Cane Spot**, **Dieback** of red and black raspberry, dewberry.

Atropellis

Ascomycetes, Helotiales

Apothecia black, sessile or with short stalk; asci clavate, with longer, hairlike paraphyses; spores needlelike to slightly club-shaped, hyaline, one-celled.

Atropellis apiculata. **Twig Canker**. On southern pines.
Atropellis arizonica. **Branch and Truck Canker**. On western yellow pine.

Atropellis pinicola (syn. **A. piniphila**). **Pine Branch** and **Trunk Canker**, on western white, sugar, and lodgepole pines in Pacific Northwest and California. Branches are girdled and killed, but not the trees. Perennial cankers are smooth, elongated, flattened depressions covered with bark, in which appear very small black apothecia, 2 to 4 mm in diameter.

Atropellis piniphila (*Cenangium piniphilum*, Anamorph). **Branch and Truck Canker** on lodgepole and ponderosa pines on Pacific Coast, on cultivated pines in the South. Trees 5 to 25 years old are damaged by deformation of main stem and branches. Infection is at branch whorls. Cankers are elongated, flattened depressions covered with bark and copious resin. Apothecia have short stalks, are black with brownish discs, 2 to 5 mm across.

Atropellis tingens. **Branch and Truck Canker** of native and exotic hard pines from New England and Lake states to Gulf states. Slash pine saplings are most susceptible. Smaller branches are girdled; perennial target cankers are formed on larger branches and main stems. Cankers persist for many years, but extension stops after about 10 years.

Botryodiplodia

► Blights.

Botryodiplodia gallae (see *Lasiodiplodia theobromae*). **Canker** of oak.

Botryodiplodia theobromae. **Canker** of rose, and citrus.

Lasiodiplodia theobromae (formerly *Botryodiplodia gallae*). **Canker** of oak.

Botryosphaeria

► Blights.

Botryosphaeria dothidea. **Canker**, **Gummosis**, and **Dieback** on peach, Bradford pear, thornless blackberry, sequoiadendron and sequoia.

Botryosphaeria obtusa. **Canker**, on thornless blackberry.

Botryosphaeria ribis. Saprophytic on dying tissue, and var. **chromogena**, parasitic. **Canker**, **Dieback** of at least 50 woody plants, including apple, avocado, eucalyptus, fig, forsythia, hickory, pecan, pyracantha, quince, rhododendron, sequoia, sequoiadendron, sweet gum, and willow. See under Blights for the disease caused on currant and rose, under Rots for apple and avocado diseases.

On redbud, sunken oval cankers nearly girdle branches, the fungus entering through wounds, and dead and dying twigs. On rhododendron there is a leaf spot and dieback similar to that caused by *Phytophthora* except that the surface is roughened by protruding fruit bodies. Cankers on twigs, larger branches, and trunks of willow may kill trees in a few years. Trunk lesions are very small, 1/4 to 1/2 inch, and numerous or else large, from the union of several small cankers, with fissured bark. Apples have watery blisters on bark and decline in vigor. Forsythia has affected canes girdled and killed with conspicuous brown dead leaves above the canker.

Control. Prune and burn dead twigs and heavily infected branches; paint wounds with a disinfectant followed by tree paint; avoid injuries. Copper sprays may help.

Botryosphaeria stevensii. Canker, on juniper.

Botrytis

► Blights.

Botrytis cinerea. **Canker** of rose.

Caliciopsis

Ascomycetes, Coryneliales

Stroma lobed, each lobe containing a single locule, which is finally wide open; perithecia stalked; asci on long slender stalks; spores dark, one-celled.

Caliciopsis pinea. **Pine Canker** on eastern white pine and other species, also on Douglas fir. Cankers are sharply depressed areas in bark, reddish brown and smoother than rest of bark, up to several inches in diameter. Small, globose, clustered black pycnidia, and stalked perithecia looking like slender black bristles, arise from stroma in cankered bark. The disease is most serious on suppressed saplings.

Encoelia (Cenangium)

► Blights.

Cenangium singulare (see *Encoelia pruinosa*). **Sooty-Bark Canker** of aspen, on *Populus tremuloides* in Rocky Mountain area.

Encoelia pruinosa (formerly *Cenangium singulare*). **Sooty-Bark Canker** of aspen, on *Populus tremuloides* in Rocky Mountain area. Cankers on older trees, at any point on trunk up to 60 to 70 feet may extend 10 to 15 feet before they girdle the tree. The bark is sooty black with a thin white outer layer.

Ceratocystis (Ceratostomella)

Ascomycetes, Micrascales

Perithecia with very long beaks, carbonaceous or leathery; ascospores hyaline, one-celled; brown, ovoid conidia and one-celled rodlike endospores formed inside tubelike conidiophores and extruded endwise. Some species are important tree pathogens; see Oak Wilt and Dutch Elm Disease under Wilts.

Ceratocystis fimbriata f. sp. platani (*Endoconidiophora fimbriata* f. sp. *platani*). **Canker Stain of London Plane**, **Plane Blight**, on London plane and also on American plane or sycamore. This serious disease started as a killing epidemic in the Philadelphia area about 1935, destroying city shade trees by the thousands there and in Baltimore during the next few years. The disease now extends from New Jersey to North Carolina and Mississippi. Trees show sparse foliage, smaller leaves, and elongated sunken cankers on trunks and larger branches. Cross sections through cankers reveal blue black or reddish brown discoloration of wood, usually in wedge-shaped sectors. First year cankers may not be more than 2 inches wide and a yard or so long, but they widen annually, girdling and killing trees in 3 to 5 years. Several cankers coalescing around the trunk kill more quickly. Once infection starts, the tree is doomed.

Ascospores and the two types of conidia are produced in moist spring weather (see Fig. 3.15). They may be spread by rain a short distance, but most dissemination is by man in pruning operations, and ordinary tree paint car-

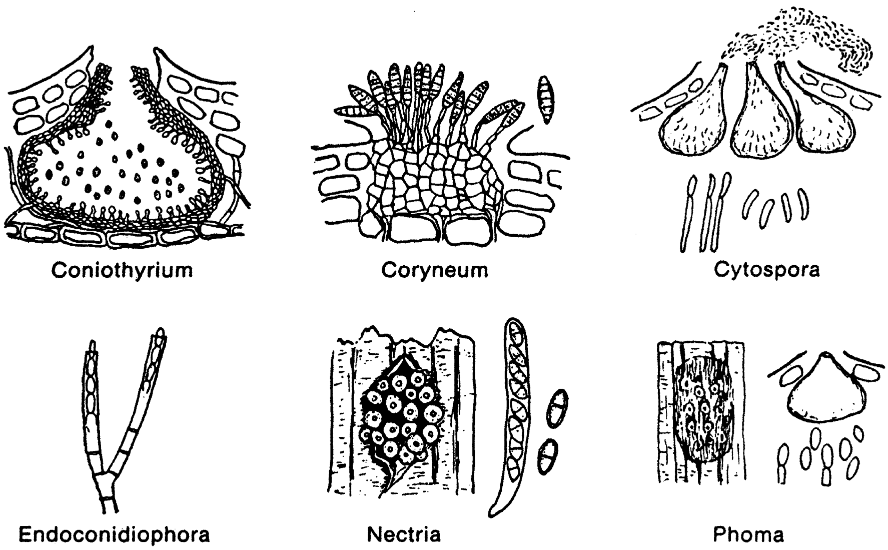


Figure 3.15 Spore Formation of Some Canker Fungi. *Coniothyrium*, small dark spores on short conidiophores in pycnidium; *Seiridium*, formerly *Coryneum*), dark, septate spores in acervulus; *Cytospora*, sausage-shaped spores in valsoid pycnidia expelled in cirrhi; *Endoconidiophora*, spores formed on inside of conidiophores; *Nectria*, two-celled bright ascospores in reddish perithecia clustered on bark; *Phoma*, hyaline spores in pyncnidia formed in spots on bark

ry viable spores. Some beetles may be vectors. Infection is solely through wounds.

Control. Do not try to save trees where trunk has been invaded; diseased branches may sometimes be removed, cutting at least 3 feet from infected area. Do not prune unless absolutely necessary and then only in winter when trees are less susceptible. Use tree wound dressing fortified with a disinfectant.

Ceratocystis sp. **Canker** and **Dieback** on poplar.

Chondropodium

Deuteromycetes, Coelomycetes

Pycnidia stromatic, stalked, columnar, externally black, hard, internally gelatinous; conidiophores simple; conidia hyaline, with several cells, crescent- or sickle-shaped; weakly parasitic or saprophytic.

Chondropodium pseudotsugae. **Bark Canker** of Douglas-fir. This is a superficial canker with outer layers of bark killed over small, circular to elliptical areas, in which pycnidia project as short, blunt, black spines. Trees are not noticeably injured.

Colletotrichum

► Anthracnose.

Colletotrichum acutatum. **Canker** and **Dieback** on Japanese maple.

Coniothyrium

Deuteromycetes, Hyphomycetes

Pycnidia black, globose, separate, erumpent, ostiolate; conidiophores short, simple; conidia small, dark, one-celled, ovoid or ellipsoid; parasitic or saprophytic (see Fig. 3.15).

Coniothyrium fuckelii (Anamorph, *Diapleela coniothyrium*). **Rose Commom Canker**, **Stem Canker**, widespread on rose, also causing raspberry cane blight (see *Leptosphaeria* under Blights), sometimes associated with apple rots, peach cankers, and stem canker of Virginia creeper. Of the three species of *Coniothyrium* that cause rose cankers, *C. fuckelii* is by far the most common. Any plant part may be affected. Pycnidia have even been found within blackspot lesions on leaves, but this is primarily a cane disease, starting as a red or yellow spot on bark, drying out and turning brown as it increases in size, with the epidermis somewhat wrinkled and perhaps rupturing irregularly over sooty masses of very small, olive brown spores. The stem may be girdled with dieback to that point.

Stem cankers are found around insect punctures, thorn pricks, leaf or thorn scars, or abrasions caused by tying, but the majority of cankers are formed at the cut end of a cane when a stub has been left in pruning above a leaf axil or bud. Roses cut properly close to a bud seldom develop this canker. A rose stub usually dies back to the first node, and since this fungus is a weak parasite, it starts most readily in such dead or dying tissue. When a cut is made close to the node, it is quickly callused over, and the callus is a good defense against wound fungi.

Control. Prune out cankered and dying stems as soon as noticed. Make all cuts just above a bud or leaf axil, not only at spring pruning but in cutting flowers for the house or cutting off dead blooms during the season.

Coniothyrium rosarum. **Rose Graft Canker**. This is a disease of roses under glass, starting at the union of stock and scion in the warm moist propagating frame and continuing in a large amount of dead wood when plants are removed to the greenhouse bench. Some consider the pathogen a form of *C. fuckelii*. Having measured spores of the type specimen, in the Kew Herbarium, I think they are distinct species, but that some cases of graft canker are due to the common canker fungus.

Coniothyrium wernsdorffiae. **Rose Brand Canker**, a rather rare but very serious disease. The pathogen was named in Germany in 1905 and was not reported in this country until 1925, although it was subsequently shown to have been collected in Canada in 1912 and in Pennsylvania and Minnesota in 1914 and 1916. In 1926 a severe epiphytotic appeared at Ithaca, New York, in the Cornell rose garden, infecting about 90% of the climbers so seriously that the canes had to be cut to the ground. Since then it has been reported from a few other states, but in several instances it has been confused with common canker.

Small, dark reddish spots on canes enlarge and acquire a more or less definite reddish brown or purple margin, contrasting sharply with the green of the cane. The center of the spot turns light brown as the cells die, and little longitudinal slits appear over the developing pycnidia. Spores are olive brown, nearly twice the size of *C. fuckelii*, and released through epidermal slits instead of being spread in a sooty mass under the epidermis. Cankers formed under the winter protection of soil are black when roses are first uncovered in spring, which explains the name *Brandfleckenkrankheit*, meaning fire-spot disease.

C. wernsdorffiae is a cold temperature fungus, infecting rose canes under the winter covering, entering through insect wounds, thorn scars, scratches, and occasionally through dormant buds. During a 4-year investigation at Ithaca, I found no infection on canes not hilled with earth or other moist cover over winter and no natural infection during the summer.

Control. Omit the usual winter protection of soil or other materials that keep canes moist. If brand canker is a problem, just fasten canes of climbers down near the ground, uncovered, and hope for the best. Loss from winter injury will be less than from the canker. Cut out diseased canes carefully.

Seiridium (Coryneum)

► Blights.

Coryneum cardinale (see *Seiridium cardinale* (*Leptosphaeria* sp., Telemorph)). **Coryneum Canker** of Cypress, **Bark Canker** of cypress, incense ceder, common juniper and oriental arborvitae.

Coryneum foliicola. **Twig Canker**, **Fruit Rot**, widespread on apple, affecting twigs, foliage and fruit.

Seiridium cardinale (formerly *Coryneum cardinale* (*Leptosphaeria* sp., Telemorph)). **Coryneum Canker** of Cypress, **Bark Canker** of cypress, incense ceder, common juniper and oriental arborvitae. This disease, since its discovery in 1927, has been gradually exterminating Monterey Cypress in most parts of California and is also serious on Italian cypress. Twigs, branches, and whole trees turn sickly, lose their leaves, and finally die.

The fungus attacks living bark and cambium, girdling twig and branch. Cankers appear first at base of lateral twigs; they are slightly sunken, dark, resinous, rough, with black spore pustules. Conidia have dark median cells, five cross-walls (see Fig. 3.15). They are spread by tools, in nursery stock, by wind and rain, and perhaps by birds and insects. Infection appears first in upper parts of trees, usually in spring during moist weather. Yellowing and browning of foliage together with gummy ooze at the cankers form conspicuous symptoms.

Control. Drastic surgery, removing wood well below infected parts, and spraying foliage heavily with bordeaux mixture help some, but with heavy infection the price of saving healthy trees is the removal and destruction of all diseased specimens. California citizens, threatened with the loss of the famous native stands of Monterey cypress at Point Lobos and Cypress Point, voluntarily destroyed their own plantings by the thousands.

Cryphonectria

Ascomycetes, Diaporthales

Production of perithecial ascocarps produced in a stroma of fungal and substrate tissues or directly from somatic hyphae on the substrate. Ascospores are hyaline to brown and one-to-several-septate.

Cryphonectria parasitica. **Canker** on oak.

Cryptodiaporthe

Ascomycetes, Sphaeriales, Valsaceae

Like *Diaporthe* but without blackened zones in substratum; spores hyaline, two-celled.

Amphiporthe aculeans (formerly *Cryptodiaporthe aculeans*; *Sporocybe rhois*, Anamorph). **Dieback**, **Canker** of sumac.

Amphiporthe castanae (formerly *Cryptodiaporthe castanea*). **Dieback**, **Canker** of Asiatic Chestnut, widespread, chiefly on seedlings or on larger trees in poor sites. Canker starts as a brown discoloration of bark of the trunk, limb, or twig, often girdling twig and then invading larger branch. Leaves on girdled branches wilt without yellowing, turn brown, and die. Bark splitting over callus formation at edge of diseased area forms pronounced canker. Conidia, two-celled, fusoid, are formed in pustules in bark; beaked perithecia are formed in groups by midsummer.

Control. Maintain vigor; plant on well-drained, fertile soil. Prune out diseased portions several inches below affected area.

Crytodiaporthe aculeans, **Sporocybe rhois, Anamorph** (see *Amphiporthe aculeans*). **Dieback**, **Canker** of sumac.

Cryptodiaporthe castanea (see *Amphiporthe castanae*). **Dieback**, **Canker** of Asiatic Chestnut, widespread, chiefly on seedlings or on larger trees in poor sites.

Cryptodiaporthe salicella. **Twig and Branch Canker** of willow.

Cryptomyces

Ascomycetes, Rhytismatales

Apothecia effuse, splitting irregularly; paraphyses present; spores hyaline, one-celled.

Cryptomyces maximus. **Blister Canker** on common and purple osier.

Cryptosporella

Ascomycetes, Diaporthales

Perithecia in a circle in a stroma, with long necks converging in a common canal; spores one-celled, hyaline; conidia borne on surface of stroma.

Cryptosporella umbrina. **Rose Brown Canker**, a widespread and serious rose disease, first reported in Virginia in 1917 but known from herbarium specimens to have been present since 1903. The fungus was first placed in *Diaporthe* because of occasional two-celled spores.

Symptoms are most noticeable on canes, starting with very small purplish spots, the center soon turning white with a reddish purple margin (see Fig. 3.16). Many small spots may be grouped on a single cane. During the winter, and especially on portions of canes covered with earth, cankers or girdling lesions are formed, often several inches long, with tan centers and purplish borders. In moist weather the surface of these large cankers is covered with yellow spore tendrils from pycnidia just under the bark; asci are also extruded in tendrils from perithecia.

Leaf spots are small purplish specks or larger dead areas, cinnamon buff to white, bordered with purple and with black pycnidia in the center. Marginal spots are subcircular. Buds are sometimes blighted; exposed petals of flowers have cinnamon-buff spots without the purple border. Infection is through wounds and also uninjured tissue.

Control. The best time to take care of brown canker is at spring pruning. Cut out every diseased cane possible. A dormant lime sulfur spray, immediately after pruning, kills spores that may have been spread in the process and may inhibit the fungus in initial lesions. Copper or sulfur sprays largely prevent summer infections. Brown canker is more likely to be serious where roses are overprotected for winter with salt, hay, leaves, or other material added to the mound of soil. I have no trouble with brown canker when roses are left unhilled over winter.

Cryptosporella viticola. **Dead-Arm Disease** of grapes, **Branch Necrosis**, widespread, especially in the Northeast, serious in Illinois, important in California. Small, angular spots with yellowish margins and dark centers are formed on leaves, stems of flower clusters and canes. The latter may split to diamond-shaped cankers, and by the next season the arm is dead or producing yellowed, dwarfed and crimped foliage. Lesions on cluster stems advance into fruit late in the season causing rotting. Pycnidia are developed on old wood; infection is often through pruning wounds.

Control. Make pruning cuts at least 6 inches below the lower margin of the infected part. Spray with bordeaux mixture when spores are extruded.

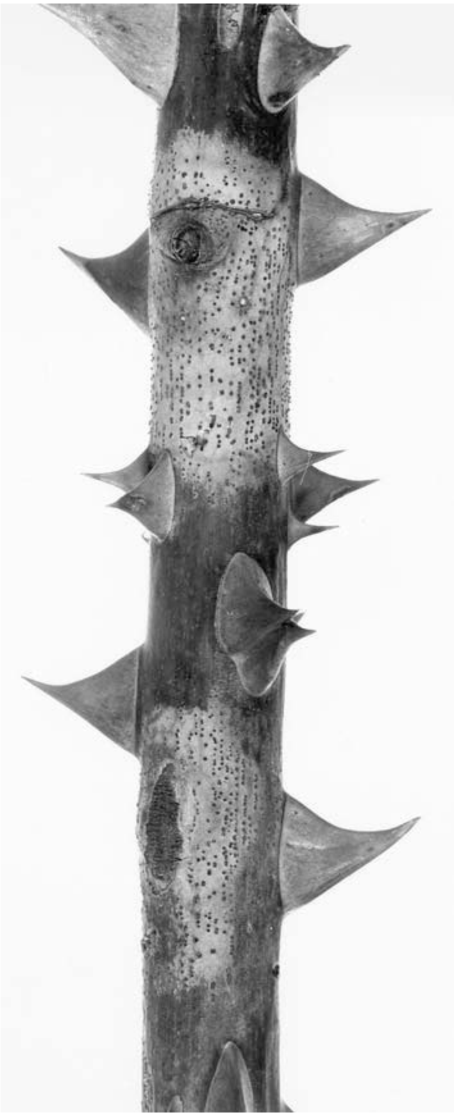


Figure 3.16 Brown Canker on Rose

Cryptosporium

Deuteromycetes, Coelomycetes

Acervuli erumpent, becoming cup-shaped or disclike; stroma brownish; conidiophores simple or branched; conidia hyaline or subhyaline, one-celled filiform.

Cryptosporium minimum. Canker on rose, not common.

Cryptosporium pinicola (see *Gelatirosporium piricola*). **Canker**, **Branch Mortality** of *Abies* spp.
Gelatirosporium piricola (formerly *Cryptosporium pinicola*). **Canker**, **Branch Mortality** of *Abies* spp.

Cylindrocarpon

► Rots.

Cylindrocarpon didymium. **Bole Canker** on apple.
Cylindrocarpon cylindroides. **Canker**, **Branch Mortality** of *Abies* spp.

Cylindrocladium

► Blights.

Cylindrocladium scoparium. **Crown Canker** of rose. The cane is attacked at or just below the union of stock and scion, the bark darkening into a black, water-soaked punky region. The cankers girdle but do not kill the canes; there are fewer and more inferior blooms. The disease was long thought confined to greenhouse roses but has appeared once or twice in outdoors fields. The fungus lives in the soil and enters through wounds in the presence of sufficient moisture. Before planting of fresh stock, greenhouse benches should be washed with boiling water and soil sterilized or changed.
The same fungus injures seedling conifers in nursery rows, causing damping-off, root rot, stem canker and needle blight to white pine and Douglas-fir. See under Blights for a discussion of the pathogen on cuttings of azaleas and other ornamentals.

Cytospora

Deuteromycetes, Coelomycetes

Cosmopolitan species, anamorph state of *Valsa*. Pycnidia in a valsoid stroma with irregular cavities, incompletely separated; conidia hyaline, one-celled, allantoid, expelled in cirrhi (see Fig. 3.15).

Cytospora abietis. **Canker**, **Branch Mortality** of *Abies* spp.
Cytospora pruinosa. **Canker**, **Dieback** of ash, on twigs and branches.

Cytospora chrysosperma (Teleomorph, *Valsa sordida*). **Cytospora Canker** of poplar, aspen, cottonwood, willow, occasional on mountain-ash, maple, cherry, and elder. Cankers form on trunks and large branches, most often on trees of low vigor. Bark is discolored in more or less circular areas; sapwood is reddish brown. In old cankers exposed wood is surrounded by layers of callus tissue. In moist weather spring spore tendrils are extruded from pycnidia in dead bark. Perithecia are found infrequently in aspen, arranged circularly around a grayish disc; they are flask-shaped with long necks pushing through the bark. Twigs and small branches may die back without a definite canker. The fungus is often present on healthy trees, not becoming pathogenic until the trees are weakened by neglect, drought, pollarding or other causes. Entrance is through wounds. Lombardy and Simon poplars are frequently killed.

Control. Remove dead and dying branches and trees with extensive cankers. Avoid wounds; feed and water as necessary. Plant poplars that are less susceptible than Lombardy. Rio Grande cottonwood is resistant to twig blight.

Cytospora kunzei (Teleomorph, *Leucostoma kunzei*). **Cutospora Canker** of spruce. **Twig Blight**, common and serious New England to the Midwest. Cankers start around bases of small twigs or on trunks. Browning and death of Colorado blue spruce branches starts near the ground and progresses upward, a large flow of resin on affected limbs. Needles drop immediately or persist for a time. Cankers are formed near resin spots and yellow tendrils extruded. Spores are splashed by rain and wind to other branches; infection is mostly through wounds.

Another form of the pathogen, *Valsa kunzei* var. *superficialis*, occurs on pine and variety *kunzei* on balsam fir, Douglas-fir, larch and hemlock.

Control. There are no satisfactory control measures except removal of diseased branches and perhaps carefully excising cankered bark. Spraying with bordeaux mixture has been recommended but is seldom very effective. Avoid wounding ornamental trees with lawn mowers; sterilize pruning tools between cuts; feed to renew vigor.

Cytospora leucostoma. **Canker** of black cherry.

Cytospora nivea. **Canker**, **Dieback** of poplar and willow, similar to that caused by *C. chrysosperma*; occasional.

Cytospora leucosperma. **Branch Canker** of elder.

Cytospora sp. **Canker** on alder and pecan.

Cytospora spp. **Cytospora Canker** of Italian Prunce, causing severe injury to prune and apricot in Idaho orchards since 1951, also present on cherries, peach, apple and willows. Some orchards have been lost, others hard hit. Symptoms are yellow to brown flags of dead leaves and erumpent, gummy cankers or elongated necrotic streaks in the bark. All suspicious wood should be cut out, hauled out of the orchard, and burned.

► *Valsa cincta* for further discussion of cankers on stone fruits.

Dasyscyphus

Ascomycetes, Helotiales, Helotiaceae

Apothecia stalked, white and hairy on the outside with a bright disc; paraphyses filiform; asci inoperculate; spores elliptical to fusoid.

Dasyscyphus agassizi (see *Lachnellula agassizii*). Common on blister-rust lesions of white pine; saprophytic on dead branches.

Dasyscyphus calycina (*Trichoscyphella hahniana*) (see *Lachnellula subtilissima*). On larch and fir, ordinarily a saprophyte but can be a weak parasite; occasional on blister-rust cankers.

Dasyscyphus ellisiana. **Canker** of Douglas-fir and pine in eastern United States. This is a native fungus on twigs and branches of native and introduced pines and on basal trunk and branches of Douglas-fir. Bark on trunk may be infected for 10 to 15 feet, with copious resin flow and numerous swellings, but trees are not killed. Apothecia are short-stalked, covered with white hairs, with an orange to yellow disc, 2 to 4 mm across. Remove trees with trunk cankers.

Dasyscyphus pseudotsugae (see *Lachnellula pseudotsuga*). **Canker** on Douglas-fir. Swollen open cankers, 2 to 3 inches long, are formed on suppressed saplings.

Dasyscyphus resinaria (see *Lachnellula resinaria*). **Canker** on balsam fir. Swollen cankers at base of branches; younger stems girdled and killed.

Dasyscyphus willkommii (see *Lachnellula willkommii* (*Trichoscyphella willkommii* syn. *Lachnellula wilkommii*)). **European Larch Canker**. Found in Massachusetts in 1927 on nursery stock from Great Britain.

Lachnellula agassizi (formerly *Dasyscyphus agassizi*). Common on blister-rust lesions of white pine; saprophytic on dead branches.

Lachnellula pseudotsuga (formerly *Dasyscyphus pseudotsugae*). **Canker** on Douglas-fir. Swollen open cankers, 2 to 3 inches long, are formed on suppressed saplings.

Lachnellula resinaria (formerly *Dasyscyphus resinaria*). **Canker** on balsam fir. Swollen cankers at base of branches; younger stems girdled and killed.

Lachnellula subtilissima (formerly *Dasyscyphus calycina* (*Trichoscyphella hahniana*)). On larch and fir, ordinarily a saprophyte but can be a weak parasite; occasional on blister-rust cankers.

Lachnellula willkommii (formerly *Dasyscyphus willkommii* (*Trichoscyphella willkommii* syn. *Lachnellula wilkommii*)). **European Larch Canker**. Found in Massachusetts in 1927 on nursery stock from Great Britain. Infected trees were removed and the fungus not seen again until 1935, near the original location. Perennial branch or trunk cankers are flattened depressions, swollen on the flanks and on the opposite side of the stem. Neighboring bark is somewhat cracked and dark with heavy exudation of resin. Cup-shaped apothecia are 3 to 6 mm across with white hairs and orange to buff discs, very short stalks. Young trees may be killed; older trees usually survive. Frost wounds are a contributing but not an essential factor. Promptly remove all trees showing cankers; continue periodic inspection.

Dermea (Dermatea)

Ascomycetes, Helotiales

Apothecia small, brownish to black with a circular opening; innate at first, on a stromoid base, rupturing host at maturity; spores one-celled, hyaline, globose to oblong. Cup fungi (ascocarp cup-shaped); excipulum of subglobose cells; sclerotia absent.

Dermatea acerina (see *Dermea acerina*). **Bark Canker** of maple, occasional.

Dermatea balsamea (see *Dermea balsamea*). **Twig Canker** of hemlock.

Dermatea livida (see *Pezicula livida*). **Bark Canker** of redwood.

Dermea acerina (formerly *Dermatea acerina*). **Bark Canker** of maple, occasional.

Dermea balsamea (formerly *Dermatea balsamea*). **Twig Canker** of hemlock.

Dermea pseudotsugae. **Branch Canker** on fir.

Pezicola livida (formerly *Dermatea livida*). **Bark Canker** of redwood.

Diaporthe

► Blights.

Cryphonectria cubensis (formerly *Diaporthe cubensis*). **Canker** of *Eucalyptus* spp.

Diaporthe eres. **Canker**, **Dieback** of English holly in the Northwest. The fungus name is a species complex that may include a *Diaporthe* on rose petals and one causing a peach constriction disease.

Diaporthe cubensis (see *Cryphonectria cubensis*). **Canker** of *Eucalyptus* spp.

Diaporthe eres. **Canker**, **Dieback** of English holly in the Northwest.

Diaporthe helianthi. **Canker** of sunflower; also leaf spot of sunflower.

Diaporthe oncostoma. **Canker**, **Dieback** of black locust.

Diaporthe phaseolorum var. **caulivora**. **Canker** of painted spurge, prickly sida, redweed, morning-glory, black nightshade, jacquemontia, hemp sesbania, indigo, spiny amaranth, vetch and soybean.

Diaporthe pruni. **Twig Canker** on black cherry; *D. prunicola* on American plum.

Dichotomophthora

Deuteromycetes, Hyphomycetes

Conidiophores brown, branching dichotomous to subdichotomous, elongated, terminal branches 4–8 lobed each lobe bearing single conidium; conidia dark, ovoid to elongate–ovoid, 1 to 6 celled.

Dichotomophthora portulacae. **Stem Canker** and **Root Rot** on common purslane.

Pseudomassaria (Didymella)

► Blights.

Didymella sepincoliformis (see *Pseudomassaria sepincolaeformis*). **Dieback** of rose.

Pseudomassaria sepincolaeformis (formerly *Didymella sepincoliformis*). **Dieback** of rose.

Diplodia

► Blights.

Diplodia sp. **Rose Dieback**, sometimes after drought and other contributing factors. In Texas the disease is most evident in autumn, progressing on roses in storage or overwintering in the ground. Canes die from tip downward, often starting in the flower stem. Diseased wood turns brown or black, and is somewhat shriveled. Pycnidia are produced in dead canes. Improve general rose vigor; use fungicides as for blackspot. May also cause canker of Russian olive.

Diplodia camphorae. **Canker**, **Dieback** of camphor-tree.

Diplodia infuscans (see *Sphaeropsis hyalina*). **Ash Canker** and **Dieback**, northeastern states.

Diplodia juglandis. **Dieback**, widespread on branches of walnut.

Diplodia mutila. **Stem Canker** on Laburnum. **Branch Dieback** on juniper.

Diplodia natalensis (see *Lasiodiplodia theobromae*). **Stem Canker** of prickly-ash; **Dieback** of citrus twigs, also causing citrus stem-end rot.

Diplodia quercina. **Canker** and **Blight** of oaks.

Diplodia sophorae. **Dieback** of pagoda tree.

Diplodia sycina. **Canker**, **Dieback** of fig.

Lasiodiplodia theobromae (formerly *Diplodia natalensis*). **Stem Canker** of prickly-ash; **Dieback** of citrus twigs, also causing citrus stem-end rot. ► Rots.

Sphaeropsis hyalina (formerly *Diplodia infuscans*). **Ash Canker** and **Dieback**, northeastern states.

Discella

Deuteromycetes, Coelomycetes

Pycnidia cupulate or discoid; spores 2-celled, hyaline.

Discella carbonacea (see *Discella microsperma*). **Twig Canker** of willow.

Discella microsperma (formerly *Discella carbonacea*). **Twig Canker** of willow.

Dothichiza

Deuteromycetes, Coelomycetes

Pycnidia innate, finally erumpent; conidiophores lacking; conidia hyaline, one-celled.

Discosporium populeum (formerly *Dothichiza populea*). **Dothichiza Canker** of poplar; **European Poplar Canker**, widespread but sporadic as a branch and trunk canker. Lombardy poplars are most susceptible, but hosts include black and eastern cottonwoods, balsam, black and Norway poplars. Japanese poplars are rather resistant. Young trees in nurseries are most injured, cankers often starting around wounds. They start as slightly darker, sunken areas, often at base of twigs and limbs, and become elongated. The bark is killed to the cambium; sapwood is brown. If a stem is completely girdled, it dies; otherwise, callus formation goes on through the summer, over the canker. In time diseased bark turns brown and cracks. Spores are extruded in amber tendrils, drying to brown, and are washed to wounds in the wood.

Control. Destroy infected stock in nurseries and plantations; do not move stock from a nursery where the disease is known. Avoid pruning and other wounds so far as possible; sterilize tools between cuts. Spraying nursery trees with bordeaux mixture in spring may be helpful.

Dothichiza populea (see *Discosporium populeum*). **Dothichiza Canker** of poplar; **European Poplar Canker**, widespread but sporadic as a branch and trunk canker.

Dothiora

Ascomycetes, Pseudosphaeriales

Ascocarps hairy and phragonosporous or muriform ascospores are colored.

Dothiora polyspora (see *Sydowia dothideoides*). **Canker** of aspen.

Sydowia dothideoides (formerly *Dothiora polyspora*). **Canker** of aspen.

Dothiorella

Deuteromycetes, Coelomycetes

Pycnidia dark, globose, grouped in a subcortical stroma; conidiophores simple, short; conidia hyaline, one-celled, ovoid to ellipsoid; parasitic or saprophytic on wood.

Botryodiplodia gallae (formerly *Dothiorella quercina*). **Dothiorella Canker** of oak, very destructive to red and white oaks in Illinois, affecting twigs, branches, and occasionally trunks. Cankers are dark brown, elongated, sunken, often with cracks at the margin. Pustules of pycnidia develop in bark and erupt through cracks, spores oozing on the surface. Sapwood has dark streaks.

Dothiorella fraxinicola. **Branch Canker** of ash.

Dothiorella quercina (see *Botryodiplodia gallae*). **Dothiorella Canker** of oak, very destructive to red and white oaks in Illinois, affecting twigs, branches, and occasionally trunks.

Dothiorella sp. **London Plane Canker**, first noted in New York City in 1947. Infected trees have sparse, undersized foliage and narrow, longitudinal cankers on trunk and branches, varying from 1 to 4 inches wide and often extending from ground level to branch top. The bark is rough, deeply fissured; inner bark is brown, dry; sapwood is only superficially discolored. Branches wilt and die back.

Dothiorella ulmi. **Dieback**, **Wilt** of elm. ► Wilts.

Endothia

► Blights.

Endothia gyrosa. **Branch Canker** on oak.

Epicoccum

► Leaf Spots.

Epicoccum nigrum. **Canker** on thornless blackberry.

Eutypa

Ascomycetes, Xylariales, Diatrypaceae

Stroma effuse; perithecia with necks at right angles to surface.

Eutypa armeniacae syn. E. lata. **Cytosporina Dieback** of apricot and of grape; **Twig Canker** on cherry and chokecherry. Anamorph state reported from California in 1962, perithecia in 1965. Bark cankers with gum are formed at pruning wounds.

Fusarium

► Rots.

Fusarium moniliforme var. subglutinans (see *Fusarium subglutinans*). **Pitch (Branch) Cankers** and **Shoot Dieback** on southern pine species, loblolly and pond pines.
Fusarium oxysporum. **Stem Canker** on peanut.
Fusarium solani. **Stem Canker** of sweetpotato, black walnut, oak, and poinsettia.
Fusarium subglutinans (formerly *Fusarium moniliforme* var. *subglutinans*). **Pitch (Branch) Cankers** and **Shoot Dieback** on southern pine species, loblolly and pond pines.

Fusicoccum

Deuteromycetes, Coelomycetes

Pycnidia one to several in a stroma, spherical or flattened, subepidermal, erumpent; opening separately or with a common pore; conidiophores simple, short; conidia hyaline, one-celled, fusoid; parasitic or saprophytic.

Fusicoccum amygdali. **Twig Canker** of peach, increasingly important on peaches in North Atlantic coastal area. Leaf spots are large, irregular or circular, often zonate, brown with scattered pycnidia near center. Cankers at buds and bases of young twigs result in death of the distal portions; trunks of young trees may be girdled. Infections occur throughout the season at bud scales, stipules, fruit and leaf scars. Prune only in winter.
Fusicoccum elaeagni. **Canker** on Russian-olive.

Gibberella

► Blights.

Gibberella baccata. **Twig Canker** of acacia, ailanthus, apple, boxwood, mimosa, mulberry, and also on other plants where twig blight is the most important symptom. ► Blights.

Gloeosporium

► Anthracnose.

Gloeosporium sp. **Canker** on holly.
Gloeosporium sp. (*Gnomonia rubi*, Teleomorph). **Canker** on thornless blackberry.

Glomerella

► Anthracnose.

Glomerella cingulata. **Camellia Dieback**, **Canker**, widespread; sometimes on azalea, blackberry, bittersweet, rose, raspberry, soapberry, mountain-ash, and English ivy; also causing bitter rot of apple (► Rots) and anthracnose of various hosts (► Anthracnose). Camellia tips die back; leaves wilt, turn dull green and finally brown. The stem dries out, turns brown, and there is a girdle of dead bark. Elliptical cankers are present on older wood. Infection is solely through wounds, principally leaf scars in early spring but also through bark wounded by cultivating tools or lawn mowers, frost cracks, or the graft union.
Governor Moulton, Professor Sargent, and some other varieties are rather resistant; Flora Plena, Prince Eugene Napoleon, and many others are highly susceptible. Spraying with bordeaux mixture to prevent infection through leaf and bud scars gives fair control.

Cryptosporiopsis (Glutinium)

Deuteromycetes, Coelomycetes

Pycnidia innate, without a stroma; spores borne at tip and sides of conidiophores, hyaline, one-celled.

Cryptosporiopsis pruinosa (formerly *Glutinium macrosporum*). **Canker**, **Fruit Rot** of apple.
Glutinium macrosporum (see *Cryptosporiopsis pruinosa*). **Canker**, **Fruit Rot** of apple.

Griphosphaeria

Ascomycetes, Amphisphaeriales

Perithecial wall carbonaceous, mouths papillate; spores dark, with several cells.

Discostroma corticola (formerly *Griphosphaeria corticola* (Anamorph, *Seimatosporium lichenicola*). **Rose Canker**, **Dieback**. Cankers are formed near base of canes, often showing dark glistening pustules of conidia. Occasionally when the canker has girdled the cane, a large gall forms above the lesion (see Fig. 3.17). It resembles crown gall but is apparently due to interference with downward transfer of food. Cut out infected canes.

Griphosphaeria corticola (see *Discostroma corticola* (Anamorph, *Seimatosporium lichenicola*)). **Rose Canker**, **Dieback**. Cankers are formed near base of canes, often showing dark glistening pustules of conidia.

Hendersonula

Deuteromycetes, Coelomycetes

Pycnidia black, stromata, one to several per stroma, locules occurring at different levels in stroma; conidophores long, flexuous; conidia often extruded in cirrhi; at first one-celled, hyaline to yellowish, later becoming three- to four-celled and dark.

Hendersonula toruloidea. **Canker** on *Arbutus menziesii*.

Hymenochaete

Basidiomycetes, Aphyllophorales

Pileus, fruiting structure, resupinate, of several layers, with long, stiff, usually brown setae (cystidia).

Hymenochaete agglutinans. **Hymenochaete Canker** on apple, birch, hazelnut, sweetgum, mistletoe, and various young hardwoods. When an infected dead stem comes in contact with a live one, the mycelium forms a thin leathery fruiting body around the living stem, holding it to the dead stem. This resupinate structure is deep brown in the center, with a yellow margin. The stem is constricted at the point of encirclement, and the sapling usually dies in 2 or 3 years. If the dead stem is removed before girdling,

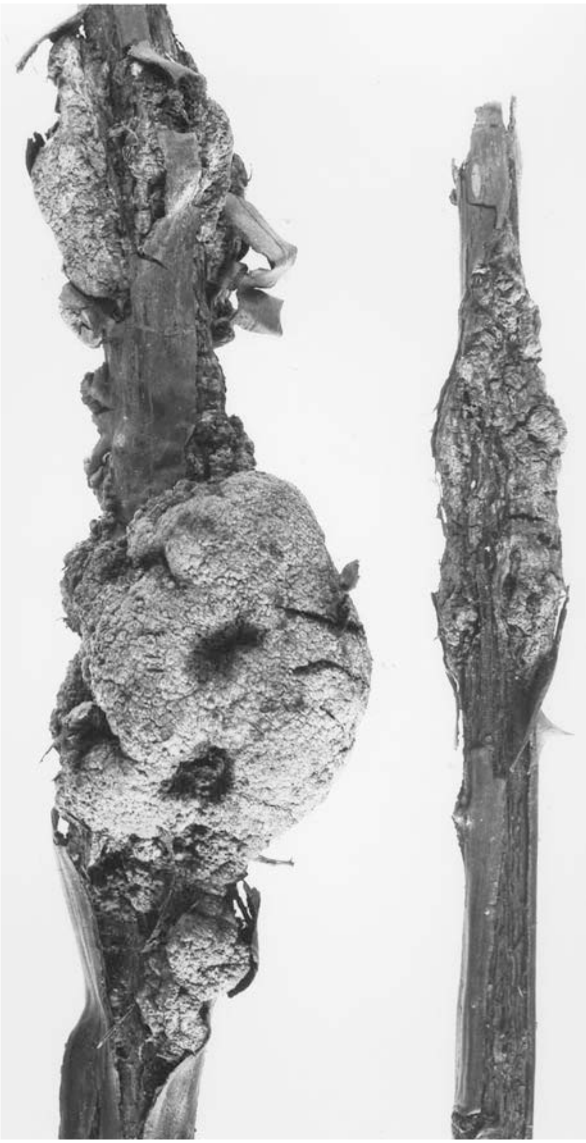


Figure 3.17 *Discostroma Canker on Rose*

a sunken canker appears on one side, but this may be overgrown with callus and disappear. Do not leave severed stems in contact with living seedlings or saplings in nursery stands.

Hypoxylon

Ascomycetes, Xylariales

Perithecia in a pulvinate stroma, often confluent and crustose; ascospores with one cell, rarely two, blackish brown; conidia in superficial layer on surface of young stroma.

Hypoxylon mammatum. **Hypoxylon Canker** of poplar. Aspen and large-tooth aspen are most commonly attacked, balsam poplar less frequently. This is usually a forest, rather than a home garden, disease. Trees less than 30 years old, growing on poor sites, are most susceptible. Trunk cankers start as small, yellow to reddish brown, slightly sunken areas, centering around a wound, there grow together to form a canker marked off by vertical cracks. The bark is mottled, gray, with black patches where the blackened cortex is exposed. Conidia appear in blisterlike stromata on first- and second-year cankers, whereas perithecia are formed on third-year cankers in hard, black stromata covered with a white pruinose coat. Ascospores are ejected in winter. Eliminate infected trees when thinning stands.

Kabatina

Deuteromycetes, Coelomycetes
Kabatina juniperi. **Blight** on eastern red cedar; conidia produced in black acervuli on discolored foliage.

Lachnellula

Ascomycetes, Helotiales

Apothecia mostly cup-shaped.

Lachnellula willkommii (Syn. *Trichoscyphello willkommii*). **Canker** of European larch (► *Dasyscypha*).

Leptosphaeria

► Blights.

Diapleella coniothyrium (formerly *Leptosphaeria coniothyrium*). **Canker** on thornless blackberry.
Leptosphaeria coniothyrium (see *Diapleella coniothyrium*). **Canker** on thornless blackberry.

Leucostoma

Leucostoma cincta. **Canker** on apple.

Macrophoma

Deuteromycetes, Coelomycetes

Like *Phoma*, with discrete pycnidia arising innately, but with much larger spores; conidia hyaline; one-celled.

Diplodia tumefaciens (formerly *Macrophoma tumefaciens*). **Branch Gall Canker** of poplar. Nearly spherical round galls, not over 1 1/2 inches in diameter, at base of twigs, which usually die; not serious.
Macrophoma candollei. Associated with **Dieback** of boxwood but apparently saprophytic only. The large black pycnidia are, however, quite striking on straw-colored leaves.
Macrophoma cupressi. **Dieback** of Italian cypress.
Macrophoma phoradendron. Defoliates mistletoe, but it grows back.
Macrophoma tumefaciens (see *Diplodia tumefaciens*). **Branch Gall Canker** of poplar.

Massaria

Ascomycetes, Pyrenulales
Spores dark, with several cells, oblong-fusiform, with mucous sheath.
Massaria platani (see *Splanchrorema platani*). **Canker**, widespread on branches of American, London, and California plane trees.
Splanchrorema platani (formerly *Massaria platani*). **Canker**, widespread on branches of American, London, and California plane trees.

Melanconis

Ascomycetes, Diaporthales

Perithecia in an immersed black stroma; paraphyses present; spores two-celled, light; conidia superficial on a stroma.

Melanconis juglandis. **Walnut Canker**, **Butternut Dieback**, widespread on butternut, also on black, Japanese, and English walnut. The disease was first described from Connecticut in 1923, but evidently was responsible for slow dying of butternuts long before that. If trees have been previously weakened, the fungus proceeds rapidly; otherwise there is the slow advance of a weak parasite. Dead limbs are sprinkled with small, black acervuli, looking like drops of ink and occasionally, in wet weather, developing spore horns of olive gray conidia. In the teleomorph state, which is rare, perithecia are embedded in the bark singly or in groups. Mycelium invades bark and wood, with a dark discoloration, and grows slowly down a branch to the trunk. When the latter is reached, the tree is doomed. In final stages trees have a stag-headed effect from loss of leaves.
Control. Remove diseased branches promptly, cutting some distance below infection; remove trees developing trunk cankers; keep the rest growing well with food and water.

Meria

Deuteromycetes, Hyphomycetes

Hyaline mycelium, branched; conidiophores simple, septate; conidia hyaline, one-celled, produced singly or in clusters.

Meria laricis, **Dieback** and **Blight**, on western larch seedlings.

Monochaetia

Deuteromycetes, Coelomycetes

Acervuli dark, discoid or cushion-shaped, subcutaneous; conidia several-celled, dark median cells, hyaline end cells, and a single apical appendage; parasitic.

Monochaetia mali (see *Seiridium unicorne*). **Canker**, **Leaf Spot** of apple.
Seiridium unicorne (formerly *Monochaetia mali*). **Canker**, **Leaf Spot** of

apple. Fungus enters through deep wounds and grows into wood, then attacks resulting wound callus and produces numerous fruiting bodies on exposed wood and callus layer. Killing of successive callus layers results in a canker similar to European apple canker. The disease is not common enough to be serious.

Nectria

Ascomycetes, Hypocreales, Nectriaceae

Perithecia bright, more or less soft and fleshy, in groups, basal portion seated on a stroma; spores two-celled, hyaline or subhyaline (see Fig. 3.15).

Nectria cinnabarina. **Dieback**, **Twig Canker**, **Coral Spot**, cosmopolitan on hardwoods, most common on maples but also found on ailanthus, amelanchier, apple, crabapple, apricot, ash, blackberry, chokecherry, beech, birch, elm, hickory, horsechestnut, mimosa, linden, paper mulberry, pear, peach, sophora, locust, and honey locust. It may also appear in stem cankers on vines and shrubs–ampelopsis, barberry, boxwood, callicarpa, cotoneaster, currant, gooseberry, fig, honeysuckle, kerria, California laurel, rose, and syringa. The fungus is widespread as a saprophyte. On ornamental trees and shrubs it is weakly parasitic, producing cankers around wounds and at base of dead branches or causing a dieback of twigs and branches.

On maple, the fungus is more pathogenic, killing twigs, small branches, young trees, and girdling larger branches. It is more frequent on Norway maple and boxelder; it may also invade red, sycamore, Japanese, and other maples. First symptoms are small, depressed, dead areas in bark near wounds or branch stubs. Conspicuous flesh-colored or coral pink sporodochia, formed in dead bark, bear conidia. Later the pustules turn chocolate brown and form pockets, in which perithecia are produced. The canker is most common in severely wounded or recently pruned trees. Sapwood has a greenish discoloration. Open cankers are eventually formed with successive rolls of callus. Remove diseased wood and bark, cutting beyond the greenish discoloration.

Nectria coccinea var. **faginata**. **Nectria Beech Bark Canker** on beech in the Northeast. The disease occurs solely in connection with the woolly beech scale insects (*Cryptococcus fagi* and *C. fagisuga*), but it has caused high mortality in Canada, killing 50% of beech stands; it is epidemic in Maine on American beech and is now present in much of New England and New York.

The scale nymphs, covered with a woolly white down, cluster thickly around cracks and wounds in bark, often making trunk and branches appear to be coated with snow. The small yellow larvae establish themselves on the bark in autumn, each inserting its sucking organ, stylet, into the living bark, which shrinks and cracks. *Nectria* enters through these cracks and kills surrounding tissue in bark and cambium. When the cells are dead, the insects can no longer obtain food; therefore, they disappear.

White pustules of sporodochia are pushed out through dead bark, bearing elongate, three- to nine-celled, slightly curved macroconidia. Red perithecia, slightly lemon-shaped, appear in clusters on the bark, often so abundant that the bark appears red. After ascospores are discharged, the upper half of the perithecium collapses and sinks into the lower. The eventual canker is a deeply depressed cavity surrounded by callus. After the cambium dies, the leaves wilt; the twigs, branches, and roots finally die.

Control. Ornamental trees can be sprayed or scrubbed to kill the insects. A dormant lime sulfur spray is very effective. Oil sprays will kill the scale but may injure beech. Late summer spraying for crawlers can supplement the dormant spray.

Nectria desmazierii (*Fusarium buxicola*, Anamorph). **Canker** and **Dieback** of boxwood (see Fig. 3.18).

Nectria ditissima. Sometimes reported but not confirmed in the United States; reports probably refer to *Nectria galligena*.

Nectria fuckeliana. **Canker** on fir.

Nectria galligena (*Cylindrosporium mali*, Anamorph). **European Nectria Canker**, **Trunk Canker**, widespread on apple, pear, quince, aspen, beech, birch, maple, hickory, Pacific dogwood, and various other hardwoods. This is one of the more important diseases of apple and pear in Europe but is less serious in this country. In eastern United States it is primarily an apple disease; on the Pacific Coast it is more common on pear.

Young cankers are small, depressed or flattened areas of bark near small wounds or at base of dead twigs or branches, darker than the rest of the bark and water-soaked. Older cankers are conspicuous and somewhat like a target, with bark sloughed off to expose concentric rings of callus. Cankers on elm, sugar maple and birch are usually circular; those on oak irregular; on basswood elongate, pointed at ends. If the canker is nearly covered with a callus roll, it indicates that the infection is being overcome.

Small red perithecia are formed singly or in clusters on bark or on wood at margin of cankers. Ascospores discharged during moist weather are dis-

Figure 3.18 Volutella Blight or "Nectria" Canker on Boxwood

seminated by wind and rain. Creamy-white sporodochia protruding through recently killed bark of young cankers produce cylindrical macroconidia and ellipsoidal microconidia. Invasion is through bark cracks or other wounds in living or dying, but not dead, wood. Infection is slow, with annual callus formation; only the smallest branches are likely to be girdled. Younger, more vigorous apple trees receiving nitrogenous fertilizer appear to be more susceptible.

Control. Remove and destroy small branches with cankers. Clean out trunk cankers and cut back to sound bark; treat with bordeaux paste. On the West Coast spray pome fruits immediately after leaf fall in autumn with bordeaux mixture to prevent infection through leaf scars.

Nectria magnoliae. **Nectria Canker**, similar to the preceding but found on magnolia and tuliptree.

Neofabraea

► Anthracnose.

Neofabraea perennans (*Gloeosporium perennans*) (see *Pezicula malicorticis*). **Perennial Canker** of apple, also bull's-eye rot of fruit.

Pezicula malicorticis (formerly *Neofabraea perennans* (*Gloeosporium perennans*)). **Perennial Canker** of apple, also bull's-eye rot of fruit. The disease is much like northwestern anthracnose. It often follows after winter injury or starts at pruning cuts where aphids congregate, or may appear after an application of wound dressing.

Nummularia

Ascomycetes, Xylariales

Stroma superficial, composed entirely of fungus elements, covered with a conidial layer when young. Perithecia flask-shaped, embedded in stroma; spores one-celled, dark.

Biscogniauxia marginata (formerly *Nummularia discreta*). **Blister Canker** of apple, crabapple, pear, mountain ash; also reported on serviceberry, birch, elm, magnolia, and honey locust. This is a major apple disease east of the Rocky Mountains, especially in Upper Mississippi and Lower Missouri River valleys, where millions of apple trees have been killed. Large and small limbs are affected. Cankers are dead areas, up to 3 feet long, mottled with living wood and dotted with numerous round cushions of stromata, looking like nailheads. Perithecia, with dark ascospores, are buried in the stromata; hyphae bearing small, light-colored conidia grow over the surface. The fungus enters through branch stubs, bark injuries, and other wounds.
Control. Avoid especially susceptible varieties like Ben Davis. Shape trees early to prevent large pruning wounds on older trees; the canker seldom appears on trees less than 10 years old. Shellac pruning cuts immediately; sterilize tools between cuts.
Nummularia discreeta (see *Biscogniauxia marginata*). **Blister Canker** of apple, crabapple, pear, mountain ash; also reported on serviceberry, birch, elm, magnolia, and honey locust.

Ophionectria (Scoleconectria)

Ascomycetes, Hypocreales

Perithecia red to white, globoid, with a round ostiole, superficial, paraphyses lacking; spores needle-shaped to filiform, light colored.

Ophionectria balsamea (see *Thyronectria balsamea*). **Bark Canker** of balsam fir.

Ophionectria scolecospora (see *Scoleconectria cucurbitula*). **Bark Canker** of balsam and alpine firs.
Scoleconectria cucurbitula (formerly *Ophionectria scolecospora*). **Bark Canker** of balsam and alpine firs.
Thyronectria balsamea (formerly *Ophionectria balsamea*). **Bark Canker** of balsam fir.

Penicillium

Deuteromycetes, Hyphomycetes

Conidia in heads; conidiophores unequally verticillate at tip in whorls; globose conidia formed in chains, one-celled, hyaline or brightly colored in mass; parasitic or saprophytic.

Penicillium vermoeseni. **Penicillium Disease** of Ornamental palms, serious in southern California with symptoms varying according to type of palm. On queen palm (*Arecastrum* or *Cocos plumosa*) the disease is a trunk canker, which may remain inconspicuous for several years but leads to weakening and breaking of trunk. Infected trees should be removed at an early stage. On Canary date palm the disease is a leafbase rot, and on Washington a bud rot. ► Rots.

Pezicula

Ascomycetes, Helotiales
Apothecia similar to *Dermatea* but lighter.
Pezicula carpinea. **Bark Canker** of hornbeam.
Pezicula corticola. **Superficial Bark Canker** and **Fruit Rot**, rather common on apple and pears. Hyaline, one-celled conidia of the *Myxosporium* stage are formed in acervuli.
Pezicula pruinosa. **Canker** on branches of amelanchier.

Phacidiella

Ascomycetes, Helotiales

Asci borne in hymenial layers, covered with a membrane until mature, then splitting; apothecia remain embedded in a stroma; paraphyses present; asci clavate.

Phacidiella coniferarum (Anamorph, *Phacidium coniferarum*). **Phomopsis Disease** of conifers. The fungus is usually saprophytic, but it is parasitic on Douglas-fir and larch in Europe and on living pine in Maine.

Phomopsis

► Blights.

Phacidiopycnis boycei (formerly *Phomopsis boycei*). **Phomopsis Canker** of lowland white fir. Branches or main stem of saplings may be girdled and killed; there is often swelling at base of canker where dead tissues join living. The reddish brown needles of dead branches are prominent against living foliage.

Phacidiopycnis piri (Teleomorph, *Potabiamyces pyri*, formerly *Phomopsis discolor*). Pear branch canker and fruit rot.

Phomopsis alnea. **Canker** of European black alder.

Phomopsis amygdali. **Branch Dieback** on almond.

Phomopsis boycei (see *Phacidiopycnis boycei*). **Phomopsis Canker** of lowland white fir.

Phomopsis discolor (see *Phacidiopycnis piri*, see Teleomorph, see *Potabiamyces pyri*). Pear branch canker and fruit rot.

Phomopsis elaeagni (Syn. *Phomopsis arnoldia*). **Canker** of Russian-olive.

Phomopsis gardeniae. (Teleomorph, *Diaporthe gardeniae*). **Gardenia Canker**, **Stem Gall**, widespread in greenhouses. Although not reported until about 1933, this seems to be the most common gardenia disease. Symptoms start with brown dead areas on stem, usually near the soil line. The canker is first sunken, then, as the stem enlarges, swollen with a rough, cracked outer cork. The stem is bright yellow for a short distance above the canker, a contrast to its normal greenish white. When stems are completely girdled, the foliage wilts and dies; the plant may live a few weeks in a stunted condition. Flower buds fall before opening. When humidity is high, black pycnidia on cankers exude yellowish spore masses. Entrance is through wounds; spores may be spread on propagating knives. Infection often starts at leaf joints at the base of cuttings after they have been placed in a rooting medium. Because the cankers may be only slightly visible on rooted cuttings, the disease may be widely distributed by the sale of such cuttings.

Control. Use sterilized rooting medium. Use steam for a sand and peat mixture. Destroy infected plants; sometimes it is possible to wait until blooms are marketed.

Phomopsis lirella (Teleomorph, *Diaporthe vincae*). **Canker**, **Dieback** of vinca, and periwinkle.

Phomopsis lokoyae. **Phomopsis Canker** of Douglas-fir mostly on saplings in poor sites in California and Oregon. Long, narrow cankers, somewhat pointed at ends, develop during the dormant season after young shoots are infected. If the tree is not girdled during the first season, the canker heals over.

Phomopsis mali. **Bark Canker** of pear, and apple. The bark is rough.

Phomopsis padina (Telomorph, *Diaporthe decorticans*). **Canker**, **Twig Blight** of sour cherry.

Phomopsis sp. **Shoot Dieback** on peach.

Phragmodothella

Ascomycetes, Dothideales

Asci in locules immersed in groups in a cushionlike stroma; spores hyaline, many-celled.

Dothiora ribesia (formerly *Phragmodothella*). **Dieback**, **Black Pustule** on currant, flowering currant, and gooseberry.

Phragmodothella ribesia (see *Dothiora ribesia*). **Dieback**, **Black Pustule** on currant, flowering currant, and gooseberry.

Physalospora

► Blights.

Botryosphaeria corticis (formerly *Physalospora corticis*). **Blueberry Cane Canker**, in Southeast on cultivated blueberries. The fungus enters through unbroken bark, probably through lenticels, with cankers starting as reddish, broadly conical swellings, enlarging the next year to rough, black, deeply fissured cankers that girdle the shoots. The portions above cankers are unfruitful and finally die. Avoid very susceptible varieties like Cabot and Pioneer.

Botryosphaeria obtusa (formerly *Physalospora obtusa* (*Sphaeropsis malorum*)). **Dieback**, **Canker** of hardwoods, New York Apple-Tree Canker, Black Rot of Apple. The fungus attacks leaves, twigs, and fruits, is more important east of the Rocky Mountains, and is found on many plants, including alder, ampelopsis, birch, bignonia, bittersweet, callicarpa, catalpa, ceanothus, chestnut, currant, cotoneaster, hawthorn, Japanese quince, maple, peach, pear, and persimmon. On hardwoods the canker is similar to that caused by *P. glandicola* on oaks. Limbs are girdled with large areas of rough bark with numerous protruding black pycnidia. For the fruit rot phase of this disease ►Rots.

Botryosphaeria quercuum (formerly *Physalospora glandicola* (*Sphaeropsis quercina, Anamorph*)). **Sphaeropsis Canker**, **Dieback** of red, chestnut, and other oaks. Shade and ornamental trees of all ages may be killed. Infection may start anywhere through wounds but more often on small twigs and branches, passing to larger branches and trunk. Twigs and branches die; leaves wither and turn brown; infected bark is sunken, and wrinkled, with small black pycnidia breaking through. On larger stems the bark has a ridge of callus around the canker, the sapwood in this area turning dark with black streaks extending longitudinally for several inches. Numerous water-sprouts grow from below the dead crown. The fungus winters on dead twigs, producing a new crop of conidia in spring, readily infecting most trees weakened by unfavorable environmental conditions.

Control. Prune out diseased portions at least 6 inches below cankers. Fertilize and water to improve vigor. Remove seriously diseased trees.

Botryosphaeria rhodina (formerly *Physalospora rhodina*). **Black Rot Canker** of tung in Mississippi and Louisiana. Black, sunken cankers on trunks, limbs, twigs, and shoots, may girdle and kill trees. Rogue and burn diseased specimens.

Glomerella cingulata (formerly *Physalospora miyabeana*). **Willow Black Canker**, accompanying scab to form the disease complex known as willow blight in New England and New York. Starting in leaf blades, the fungus proceeds through petioles into twigs; it also causes cankers on larger stems, followed by defoliation. Pinkish spore masses of the anamorph *Gloeosporium* state are formed on dead twigs and branch cankers and then short-necked perithecia, which overwinter. Remove and destroy dead twigs and branches during the dormant period. Spray 3 times with bordeaux mixture, starting just after leaves emerge in spring.

Physalospora cortices (see *Botryosphaeria corticis*). **Blueberry Cane Canker**, in Southeast on cultivated blueberries.

Physalospora glandicola (*Sphaeropsis quercina, Anamorph*) (see *Botryosphaeria quercuum*). **Sphaeropsis Canker**, **Dieback** of red, chestnut, and other oaks.

Physalospora miyabeana (see *Glomerella cingulata*). **Willow Black Canker**, accompanying scab to form the disease complex known as willow blight in New England and New York.

Physalospora obtusa (*Sphaeropsis malorum*) (see *Botryosphaeria obtusa*). **Dieback**, **Canker** of hardwoods, New York Apple-Tree Canker, Black Rot of Apple.

Physalospora rhodina (see *Botryosphaeria rhodina*). **Black Rot Canker** of tung in Mississippi and Louisiana.

Phytophthora

► Blights.

Phytophthora cactorum. **Bleeding Canker** of maple, beech, birch, elm, horsechestnut, linden, oak, sweetgum, and willow; **Crown Canker** of dogwood; **Dieback** of rhododendron; Trunk Canker of apple, almond, apricot, cherry, and peach.

Bleeding Canker, first noticed in Rhode Island on maple about 1939 and found in New Jersey the next year, is now present on many trees in the Northeast. The most characteristic symptom is the oozing of a watery light brown or thick reddish brown liquid from fissures in bark at the root collar and at intervals in trunk and branches. When dry, this sap resembles dried blood, hence the name, bleeding canker. Sunken, furrowed cankers are more definite on young trees than on older trees with rough bark. Symptoms are most prominent in late spring and early fall, with trees in moist situations most often affected. The fungus lives in the soil and advances upward from a primary root infection. Wilting of leaves and blighting of branches is evidently from a toxin. Mature trees have fewer, smaller, yellow-green leaves, and there is an acute dieback of branches. Reddish-brown areas with intense olive-green margins are found in wood extending vertically from roots to dying branches, marked at irregular intervals with cavities containing the watery fluid.

Control. Although there is no real "cure," injecting trees with Carosel, a mixture of helione orange dye and malachite green, has inhibited the fungus and neutralized the toxin. In some cases trees recover without treatment. Avoid heavy feeding; this seems to encourage the spread of disease and causes chronic cases to become acute.

Crown Canker, collar rot, is the most serious disease of dogwood reported in New York, New Jersey, and Massachusetts. The first symptom is a general unhealthy appearance, with leaves smaller and lighter green than normal, turning prematurely red in late summer. Leaves may shrivel and curl during dry spells (normal leaves often do likewise). Twigs and large branches die, frequently on one side of the tree. The canker develops slowly on the lower trunk near the soil level. Inner bark, cambium and sapwood are discolored; the cankered area is sunken; the bark dries and falls away, leaving wood exposed. Trees die when the canker extends completely around the trunk base or root collar. The fungus lives in the soil in partially decayed organic matter, and spores are washed to nearby trees. Entrance is through wounds. The disease affects transplanted dogwoods, seldom natives growing in woods.

Control. Transplant carefully, avoiding all unnecessary wounds; avoid hitting base with lawnmower, by using a wire guard around the tree. It is difficult to save trees already infected, but cutting out small cankers and painting the wound with bordeaux paste is worth trying. If trees have died from crown canker, do not replant with dogwoods in the same location for several years.

Rhododendron Dieback, is a disease in which terminal buds and leaves turn brown, roll up, and droop as in winter cold. A canker encircles the twigs, which shrivel with the terminal portion wilting and dying. In shady locations leaves have water-soaked areas, changing to brown, zonate spots. Do not plant rhododendrons near lilacs, for they are blighted by the same fungus. Prune diseased tips well below the shriveled part, and spray after blooming with bordeaux mixture, two applications 14 days apart.

Trunk Canker of Apple, is an irregular canker often involving the entire trunk and base of scaffold branches, the first outward symptom a wet area on bark. Trees must be 5-years old or older for infection. Grimes Golden and Tomkins King are especially susceptible, often being completely girdled.

Phytophthora cinnamomi. **Basal Canker** of Maple, particularly Norway maple. Trees have a thin crown, fewer and smaller leaves, and die a year or two after cankers are formed at the base of the trunk. Sapwood is reddish brown; the roots decay. Remove diseased trees. Plant new Norway maples in good soil, well drained, rich in organic matter; treat injuries at base of trunk promptly. See under Rots and Wilts for other manifestations of this pathogen.

Phytophthora syringae. **Pruning Wound Canker** of almond.

Plenodomus

Deuteromycetes, Coelomycetes

Pycnidia dark, immersed, irregular in shape and opening irregularly; conidia hyaline, one-celled, oblong; parasitic.

Aposphaeria fuscomaculans (formerly *Plenodomus fuscomaculans*). **Canker** on apple.

Plenodomus fuscomaculans (see *Aposphaeria fuscomaculans*). **Canker** on apple.

Pseudonectria

Ascomycetes, Hypocreales

Perithecia superficial, blight-colored, smooth; spores one-celled, hyaline.

Pseudonectria rousselliana. **Nectria Canker** of boxwood, **Leaf Cast**, **Twig Blight**. The perithecia are formed on dead leaves, but the fungus is thought to be the teleomorph state of *Volutella buxi*, which see.

Pseudovalsa

Ascomycetes, Diaporthales

Perithecia in a stroma; spores dark, with several cells.

Pseudovalsa longipes. **Twig Canker** on coast live oak and white oak.

Rhabdospora

Deuteromycetes, Coelomycetes

Pycnidia separate, not produced in spots, erumpent, ostiolate; conidiophores short, simple conidia hyaline, filiform to needle-shaped, with several cells; parasitic or saprophytic.

Rhabdospora rubi (see *Septocyta ruberum*). **Cane Spot**, **Canker** of raspberry.
Septocyta ruberum (formerly *Rhabdospora rubi*). **Cane Spot**, **Canker** of raspberry.

Scleroderris

Ascomycetes, Helotiales

Apothecia black, opening with lobes, crowded together or with a stroma, short-stalked; spores hyaline, elongate, with several cells.

Ascocalyx abietina (formerly *Scleroderris lagerbergii* = *Gremmeniella abietina*). **Canker** on pine.
Grovesiella abieticola (formerly *Scleroderris abieticola*). **Canker** of balsam fir, on Pacific Coast. An annual canker, starting in autumn and ceasing when cambium is active in spring, is formed on twigs, branches, and trunks of saplings. Only twigs and small branches are girdled, and if this does not happen before spring, the wound heals over. Small black apothecia with short stalks appear on dead bark. Ascospore infection is through uninjured bark or leaf scars.
Scleroderris abieticola (see *Grovesiella abieticola*). **Canker** of balsam fir, on Pacific Coast.
Scleroderris lagerbergii Syn. *Gremmeniella abietina* (see *Ascocalyx abietina*). **Canker** on pine.
Scleroderris lateritium. **Canker** on pine.

Sclerotinia

► Blights.

Sclerotinia (Syn. *Whetzelinia*) **sclerotiorum**. **Basal Canker** on Euonymus. **Stem Canker** and **Wilt** on sage.

Septobasidium

Basidiomycetes, Septobasidiales

All species are on living plants in association with scale insects; the combination causes damage to trees. Fungus body variable, usually resupinate, dry, crustaceous or spongy, in most species composed of subiculum growing over bark; a middle region of upright slender or thick pillars of hyphae supports the top layer, in which hymenium is formed. Basidium transversely septate into two, three, or four cells, rarely one-celled; basidiospores elliptical, colorless, divided into two to many cells soon after formation, budding with numerous sporidia if kept moist. Some species with conidia.

The fungus lives by parasitizing scales, obtaining food via haustoria. The insects pierce the bark to the cambium, sometimes killing young trees. The fungus kills a few scales but protects many more in its enveloping felty or leathery covering, a symbiotic relationship. Spores are spread by scale crawlers and by birds. Most felt fungi are found in the South, abundant on neglected fruit, nut, or ornamental trees, rare on those well kept.

Septobasidium burtii. **Felt Fungus** on southern hackberry, beech, pear, apple, and peach. This is a perennial growth, with a new ring added to the patch each summer. Probasidia are formed during the winter, and four-celled basidia in spring.

Septobasidium castaneum. **Felt Fungus** abundant on willow and water oaks, and holly; may injure azaleas. The surface is smooth, shiny, chocolate brown to nearly black.

Septobasidium curtisii. **Felt Fungus**, widespread on many trees in the Southeast, commonly on sour gum (tupelo) and American ash, also on hickory, hawthorn, Japanese quince, and others. The felt, purple-black throughout, is mounded over the insects.

Septobasidium pseudopedicellatum. **Felt Fungus**, on citrus twigs, sometimes on main stem or branches of hornbeam. Surface is smooth, buff-colored over dark brown pillars.

Solenia (Henningsomyces)

Basidiomycetes, Aphyllophorales

Fruiting layers erect, cylindrical, formed in groups, membranous.

Cyphellopsis anomala (formerly *Solenia* (*Henningsomyces*) *anomala*). **Bark Patch**, **Canker**, widespread on alder.

Merismodes ochracea (formerly *Solenia ochracea*). **Bark Patch** of birch, hornbeam, hickory, and alder.

Solenia (*Henningsomyces*) anomala (see *Cyphellopsis anomala*). **Bark Patch**, **Canker**, widespread on alder.

Solenia ochracea (see *Merismodes ochracea*). **Bark Patch** of birch, hornbeam, hickory, and alder.

Sphaeropsis

Deuteromycetes, Hyphomycetes

Pycnidia black, separate or grouped, globose, erumpent, ostiolate; conidiophores short; conidia large, dark, one-celled, ovate to elongate, on filiform conidiophores. Some species have *Physalospora* as the teleomorph state.

Sphaeropsis sapinea. **Bleeding Canker** on pine.

Sphaeropsis tumefaciens. **Canker** and **Gall** on *Carissa*.

Sphaeropsis ulmicola. **Sphaeropsis Canker** of American elm. The disease spreads downward from small twigs to larger branches with a brown discoloration of wood just under the bark. Secondary shoots sometimes develop below the cankers. Trees weakened by drought or poor growing conditions are particularly susceptible. Prune out infected wood, cutting well below cankers.

Stegonsporium

Deuteromycetes, Hyphomycetes

Stegonsporium sp. **Maple Canker**, **Dieback**. Reported from New Jersey. Large branches die back with conspicuous flagging. Black tarlike fruiting bodies are formed in cankers.

Strumella

Deuteromycetes, Hyphomycetes

Sporodochia wartlike, gray to black, of interwoven hyphae; conidiophores dark, branches; conidia dark, one-celled, ovoid to irregular.

Conoplea globosa (formerly *Strumella coryneoidea*). **Strumella Canker** of oak, especially the red oak group, also on American beech and chestnut, occasional on pignut and hickories, red maple, and tupelo. Primarily a forest disease, this canker may become important on red and scarlet ornamental oaks. Starting as a yellowish discoloration of bark around a dead branch or other point of infection, the canker develops into a diffuse lesion or into a target canker with concentric rings of callus. Whitish mycelium is present near outer corky bark, and the infected portion of the trunk may be flattened or distorted. Target cankers may be up to 2 feet wide and 5 feet long. The small black nodules bear no spores while trees are living, but after death dark brown spore pustules are formed, which blacken with age. New pustules are formed yearly. Canker eradication has been unsuccessful in forest stands. The diseased trees should be removed and utilized before spores can spread infection.

Strumella coryneoidea (see *Conoplea globosa*). **Strumella Canker** of oak, especially the red oak group, also on American beech and chestnut, occasional on pignut and hickories, red maple, and tupelo.

Sydowia

Ascomycetes, Dothidiales

Asci usually short, cylindrical, and relatively numerous, in spherical, ostiolate locules.

Sydowia polyspora. **Twig Dieback** on fir.

Thyronectria

Ascomycetes, Hypocreales

Stroma valsoid with several perithecia, bright-colored; spores muriform, hyaline to subhyaline.

Thyronectria austro-americana. **Canker**, **Wilt** of honeylocust. Slightly depressed cankers ranging from pinhead size to 1/2 inch grow together and enlarge to girdle a branch. Underlying wood is streaked reddish brown for several inches from the canker, and there is often a gummy exudate. Some trees die, but many survive.

Thyronectria balsamea. **Canker** on fir.

Thyronectria berolinensis. **Cane Knot Canker** of fruiting and flowering currants.

Trichothecium

► Rots.

Trichothecium roseum. **Canker** of rose.

Tubercularia

Deuteromycetes, Hyphomycetes

Forms bright colored cushions, mostly on wood or bark; fine branching conidiophores bearing small, elipsoidal hyaline conidia.

Tubercularia ulmea. **Canker** on Russian olive and honeylocust.

Tympanis

Ascomycetes, Helotiales, Helotiaceae

Ascocarp cup-shaped; sclerotia absent; expiculum usually, if parallel hyphae.

Tympanis confusa. **Canker** on pine.

Valsa

Ascomycetes, Diaporthales

Many perithecia in a circle in a stroma in bark; flask-shaped with long necks opening to the surface; spores hyaline, one-celled, curved, slender.

Leucostoma cincta (formerly *Valsa cincta*). **Perennial Canker** of peach, **Dieback**, also on nectarine. The fungus is apparently infective during the dormant season, entering through wounds, dead buds, leaf scars, and fruit spurs. It forms a canker complex with *V. leucostoma* and sometimes the brown-rot fungus. It is more common in northern latitudes than in southern, but is not important in well-cared-for orchards.

Leucostoma kunzei (formerly Valsa kunzei). ► *Cytospora kunzei.*

Leucostoma persoonii (formerly *Valsa leucostoma*). **Apple Canker**, **Dieback**, **Twig Blight** on apple, apricot, peach, pear, quince, plum, cherry, willow, and mountain-ash. The fungus is a weak parasite entering through wounds or twigs killed by frost.

Valsa cincta (see *Leucostoma cincta*). **Perennial Canker** of peach, **Dieback**, also on nectarine. **Valsa kunzei** (see *Leucostoma kunzei*). ► *Cytospora kunzei*.

Valsa leucostoma (see *Leucostoma persoonii*). **Apple Canker**, **Dieback**, **Twig Blight** on apple, apricot, peach, pear, quince, plum, cherry, willow, and mountain-ash. **Valsa salicina** (*Cytospora salicis*). **Twig and Branch Canker** of willow.

Valsa sordida. ► *Cytospora chrysosperma.*

Vermicularia

Deuteromycetes, Coelomycetes

Like *Colletotrichum* but setae are scattered throughout the acervuli, not just marginal; spores hyaline, globose to fusoid.

Vermicularia ipomoearum. **Stem Canker** of morning glory.

Volutella

► Blights.

Volutella buxi. **Boxwood "Nectria" Canker**, **Volutella Blight**. The teleomorph state of the fungus is supposed to be *Pseudonectria rousselliana*, which see. As a canker the disease often follows after winter injury, with salmon-pink spore pustules on dying twigs, branches, and main stems. As a blight, the fungus spreads rapidly in moist weather in summer, attacking healthy twigs when humidity is high and often discernible at a distance by a straw yellow "flag." On such yellowing branches the backs of leaves and the bark of twigs are both covered with the pinkish spore pustules.

Control. Cut out branches where the bark has been loosened by winter ice and snow. Have a yearly "housecleaning," brushing out accumulated leaves and other debris from interior of bushes and cutting out all twigs with pink pustules. If there are signs of disease, follow cleaning with thorough spraying, from ground up through interior of bushes, with lime sulfur.

CLUB ROOT

Plasmodiophora

Plasmodiophoromycetes, Plasmodiophorales

This genus, founded on the club root organism, has a somewhat doubtful taxonomic position. Formerly considered a slime-mold, one of the Myxomycetes, then placed in the Chytridiales, lowest order of true fungi, it is now placed in a separate order, Plasmodiophorales.

Thallus amoeboid, multinucleate in host cell; spores lying free in host cell at maturity; frequently causing hypertrophy; parasitic on vascular plants.

Plasmodiophora brassicae. **Club Root** of cabbage and other crucifers; finger-and-toe-disease, on alyssum, brussels sprouts, cabbage, Chinese cabbage, candytuft, cauliflower, hesperis, honesty, peppergrass, garden cress, mustard, radish, rutabaga, stock, turnip, and western wallflower.

Club root was present in western Europe as early as the thirteenth century, but the true cause was not known until the classic paper of the Russian Woronin in 1878. The disease was important in the United States by the middle of the nineteenth century, and is now present in at least 37 states. Losses come from death of the plants and also from soil infestation, for susceptible crucifers cannot be grown again on the same land for several years, unless it is treated. The first symptom is wilting of tops on hot days, followed by partial recovery at night; affected plants may be stunted and not dead; outer leaves turn yellow and drop. The root system becomes a distorted mass of large and small swellings, sometimes several roots swollen like sweet potatoes, and sometimes joined in one massive gall. Lateral and tap roots are scabby and fissured, with rot starting from secondary fungi.

When diseased roots decompose, small spherical spores are liberated in the soil; they are capable of surviving there many years between crops. In spring, with suitable temperature and moisture, the resting spores germinate, each becoming a motile swarm spore with a flagellum. This whiplike appendage is soon lost, and the organism becomes amoebalike, moving by protoplasmic streaming until it reaches a root hair or other root tissue. The plasmodium continues to grow and divide until it reaches the cambial cells, in which it develops up and down the root. The swelling is produced by division of plasmodia and of the infected cells. Eventually the multinucleate plasmodium breaks up into many small resting spores, each rounded up around a single nucleus. They are set free by the millions when the root rots, and are spread in soil clinging to shoes or tools and in drainage water, manure, and plant refuse. Spores are not seed-borne. Long-distance spread is probably by infected seedlings. Infection takes place chiefly in a neutral to acid soil, pH 5.0 to 7.0, at temperatures below 80°F, and when moisture of soil is above 50% of its water-holding capacity.

Control. Inspect seedlings carefully before planting. Dispose of infested crops with caution; resting spores passed through animals are still viable. A long rotation of crops has been recommended, combined with adding lime to soil, which must be applied in large amounts, about 6 weeks before the cabbage crop is set. This brings the pH too high to use potatoes as a following crop. Most turnip and rutabaga varieties are relatively resistant to strains of the club root organism present in the United States.

DAMPING-OFF

Damping-off is the destruction of young seedlings by soil organisms. There are two types. Pre-emergence damping-off rots the sprouting seed before it breaks through the soil; it is recognized by bare spaces in what should be uniform rows. Such a poor stand may be due to poor viability of seed, but more often it is due to soil fungi functioning in cold, wet soils when germination is slow. Post-emergence damping-off is the rotting or wilting of seedlings soon after they emerge from the soil. Succulent stems have a water-soaked, then necrotic and sunken, zone at ground level; the little herbaceous plants fall over on the ground or, in woody seedlings, wilt and remain upright. Root decay follows. This type of damping-off is most common in greenhouses or outdoors in warm humid weather and where seedlings are too crowded. Tree seedlings in nursery rows are subject to this type of damping-off, and so are perennial flowers started in late summer for the next year.

Many fungi living saprophytically in the upper layers of soil can cause damping-off. *Pythium debaryanum, P. mastophorum* and *Rhizoctonia solani* are probably most common, but other species of these two genera and *Aphanomyces, Botrytis*, *Cylindrocladium, Diplodia, Fusarium, Macrophomina, Helminthosporium, Sclerotium rolfsii, Fusarium equiseti*, and *Phytophthora* may be important on occasion. A synergistic interaction of *Pythium myriotylum, Fusarium solani*, and *Meloidogyne arenaria* causes damping-off of peanut which has been reported in Florida. See under Rots for details. Also, *Caloscypha fulgens* (anamorph state, *Geniculodendron pyriforme*) causes damping-off of spruce seed, *Colletotrichum gloeosporioides* of papaya, *Colletotrichum acutatum* of flowering dogwood and *Fusarium moniliforme* var. *intermedia* of pine.

Damping-off is prevented by starting seed in a sterile medium, such as vermiculite, perlite, or sphagnum moss, or by treating the soil or the seed before planting. Commercial operators treat soil with steam or electricity.

Seed treatment, the coating of seed with a protectant dust, is crop insurance. In some seasons, good stands can be obtained without it, but it scarcely pays to take a chance. Seed disinfection is used to kill organisms of anthracnose and other specific diseases carried on seed. The damping-off organisms are in the soil, not on the seed, and coating the seed with a chemical is intended to kill or inhibit fungi in the soil immediately surrounding the seed and so provide temporary protection during germination.

DODDER

Dodders are seed plants parasitic on stems and other parts of cultivated or wild plants. They are leafless, orange to yellow twining vines, without chlorophyll and hence incapable of manufacturing their own food. They are called love vine, strangle weed, gold thread, hairweed, devil's hair, devil's ringlet, pull down, clover silk, and hell-bind, the last being most appropriate. There are about 40 species in the United States, causing serious agricultural losses in clovers, alfalfa, and flax, and becoming more and more important in gardens on ornamentals and sometimes vegetables. Dodders belong to the single genus *Cuscuta*, family Cuscutaceae, close to the morning-glory family.

Dodder seed is grayish to reddish brown, resembling small legume seed but roughened with three flattened sides. It germinates as ordinary seed but is synchronized to start a little later than its host seedlings. The parasite is a slender, yellowish, unbranched thread with the growing tip circling around in search of support. When it touches the host it twines like a morning-glory and puts out little suckers, haustoria, into the stem of the victim, after which its original connection with the soil dries up (see Fig. 3.19). Although seedlings can live for a few weeks without a susceptible host, they finally die if a connection is not established. Successful parasites continue to twine and to spread orange tendrils from one plant to the next, often making a tangle of matted orange hairs many feet across, with a black region in the center where plants have died. Such tangles are conspicuous in weeds along roadsides.

In ornamental plantings host plants are not often killed but exhibit stunting and pallor, symptoms of starvation. Minute scales or rudimentary leaves form on the dodder tendrils followed by dense clusters of beautiful white blossoms (sometimes pale pink or yellow), which ripen seed in late summer, with as many as 3000 seed being produced on a single plant.

Cuscuta spp. Much of the dodder infesting ornamentals is not readily identified as to species, but it is widespread on a great many shrubs, perennials and annuals. It is found very commonly on chrysanthemum, also strangling

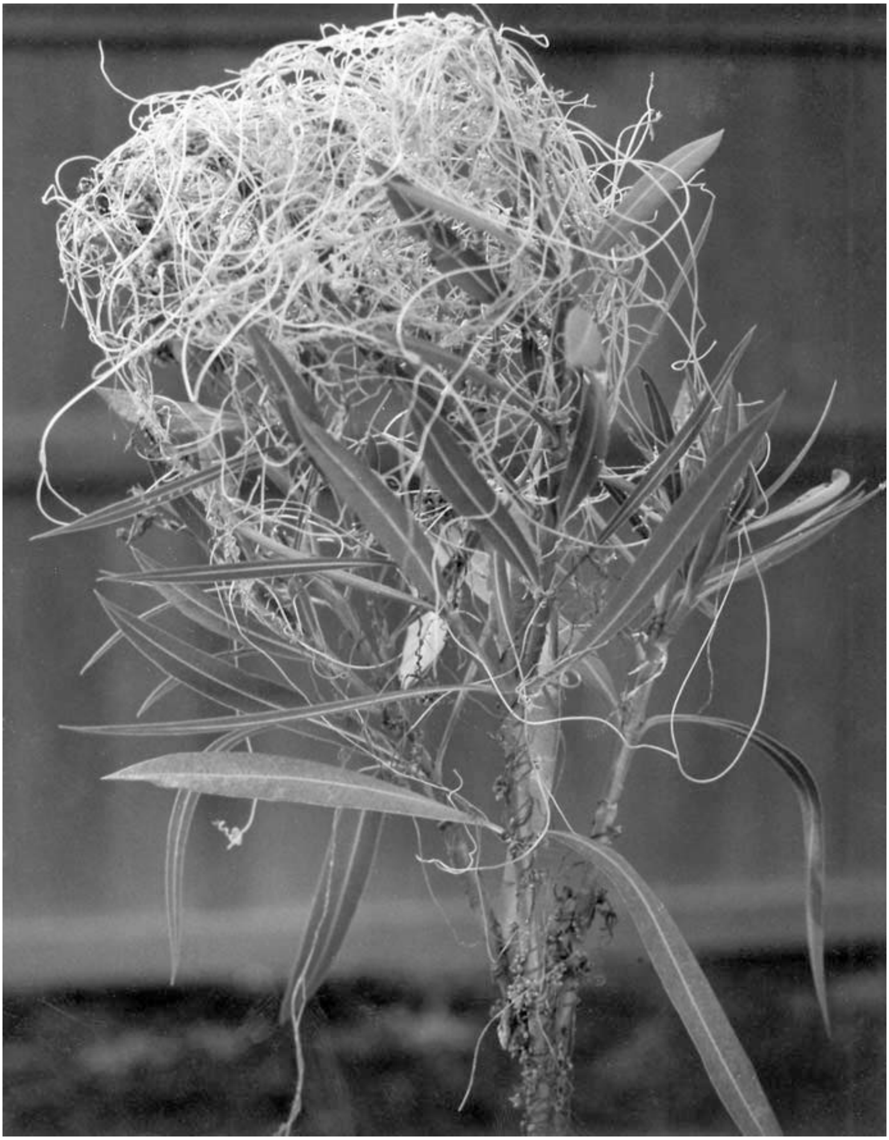


Figure 3.19 Dodder on Oleander

any other plant in the vicinity. Many hours may be spent cleaning up ivy and trumpet-vine, petunias and asters. Dodder is reported on camellias in the South. It is even a pest of house plants, if field soil has been used for the potting mixture. Dodder has, however, one virtue for plant pathologists. It is used as a bridge between plants to carry viruses and MLOs in testing their host range.

Cuscuta americana on citrus. **C. californica** on beet.

Cuscuta coryli. **Hazel Dodder**. **C. epithymum**. **Clover Dodder** on legumes.

Cuscuta exaltata on redbud, ilex, and sumac.

Cuscuta gronovii. **Common Dodder** on buttonbush, cucumber, raspberry, members of the potato family, and many garden ornamentals, including hedge plants.

Cuscuta indecora. **Bigseed Alfalfa Dodder** on alfalfa from Colorado westward, also on sweet pea and tomato.

Cuscuta paradoxa on rose, Texas and Florida.

Cuscuta pentagona (*C. arvensis*). **Field Dodder**, widely distributed, most common and serious east of Mississippi on many cultivated and wild herbaceous plants.

Cuscuta planifera. **Littleseed Alfalfa Dodder**, on some legumes in the West.

Control. Avoid dodder-infested seed. Commercial seed containing one or more dodder seed per 5-gram sample is prohibited entry into the United States. Many states have laws regulating sale of infested seed, but it may still be included inadvertently in a seed packet. If any contamination with rough, flat-sided seed is found, do not use any of the lot. Commercial dealers sometimes clean infested seed by screening or treating with an iron powder, which sticks to the rough dodder seed so it can be drawn out by magnets.

Before breaking new ground for a garden on native sod, examine it carefully. If dodder is found, burn over the area, then hoe lightly but repeatedly for several weeks to allow buried seed to germinate and die. When dodder is present on cultivated plants, the only thing to do is to remove and burn infested parts before seed is formed. Pulling off the orange tendrils is not sufficient. All parts of the plant attacked must be cut off and burned, for even a small fraction of a tendril left twined around a stem will start growing again.

A fungus, *Colletotrichum destructivum*, has been found to parasitize dodder and offers a slight possibility of biological control.

DOWNY MILDEWS

Downy mildews, sometimes called false mildews, are Oomycetes, in the order Peronosporales and all in the family Peronosporaceae except *Phytophthora* in the Pythiaceae. They form mycelium in higher plants and produce sporangiophores that protrude through stomata in great numbers, their sporangia making white, gray, or violet patches on the leaves. The downy effect distinguishes these mildews from the true or powdery mildews that form white felty or powdery patches.

The sporangiophores are often branched; they bear a single sporangium at the tip of each branch simultaneously, or successively in *Phytophthora*. Sporangia germinate by swarm spores or with a germ tube as a conidium. An oospore, resting spores with external ridges or knobs, is formed in an oogonium, large globular multinucleate female cell, after it is fertilized by the antheridium, a smaller male cell. The oospores are set free by weathering and decay of host parts.

Basidiophora

Oomycetes, Peronosporales

Sporangiophore a single trunk with a swollen apex from which short branches grow out, each bearing a nearly globose sporangium; germination by swarm spores; oospore wall not confluent with that of oogonium. Mycelium is intercellular, haustoria small, knoblike (Fig. 3.20).

Basidiophora entospora. **Downy Mildew** of aster, China aster, goldenrod, and erigeron. Aster losses are reported by commercial growers in the South, but apparently this is not an important garden problem.

Bremia

Oomycetes, Peronosporales

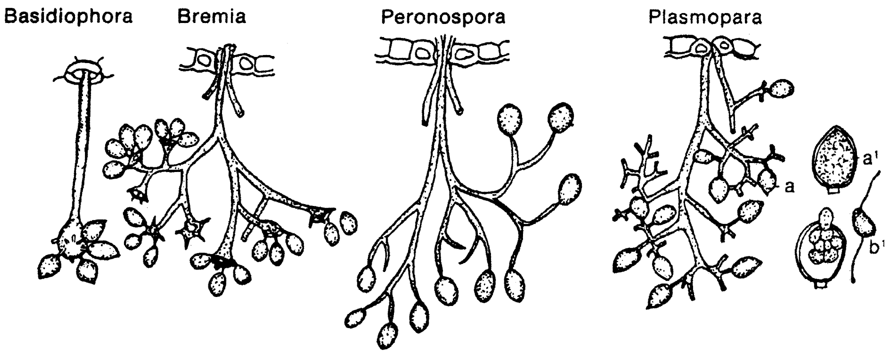


Figure 3.20 Downy Mildews Fruiting from Stomata on Underside of Leaves. *Basidiophora*, sporangiophoore with swollen apex; *Bremia*, sporangiophore tip enlarged to a disc, dichotomous branching; *Peronospora*, sporangia on sharply pointed terminal branches; Plasmopara, on obtuse tips; **a** and **a^1**, sporangium; **b^1**, zoospore

Dichotomous branching of sporangiophores; tips enlarged into discs bordered with sterigmata bearing sporangia; swarm spores rare; germination usually by a germ tube protruded through an apical papilla (Fig. 3.20).

Bremia lactucae. **Downy Mildew** of lettuce and other composites, endive, cornflower, centaurea, celtuce, escarole, romaine, and various weeds. First noticed around Boston in 1875, the disease is serious in greenhouses and in states where outdoor winter crops are grown. Light green or yellowish areas on upper surface of leaves are matched by downy patches on the under surface. Affected portions turn brown, and leaves die, the older ones first. Entrance is through stomata. The disease is worse in damp, foggy, cool weather (43° to 53°F).
Control. The pathogen has numerous physiological races so that lettuce varieties like Imperial 44 and Great Lakes that are resistant in some localities may not be so in others. Avoid excessive irrigation; eliminate crop residue and weeds.

Peronospora

Oomycetes, Peronosporales

Mycelium intercellular; haustoria in a few species short and knoblike, but in most filamentous and more or less branched. Sporangiophore with erect trunk two to ten times dichotomously branched, with branches somewhat reflexed and terminal branches sharp-pointed; sporangia colored, lacking an apical papilla, germinating from an indeterminate point on the side. Oospores smooth or variously marked, germinating by germ tubes (see Fig. 3.20).

Peronosclerospora sorghi (formerly *Peronospora sorghi*). Downy mildew, on sweet corn.

Peronospora antirrhini. **Snapdragon Downy Mildew**, reported from California, Oregon, Oklahoma, Pennsylvania, and Maryland.

Peronospora arborescens. **Downy Mildew** of prickly-poppy on leaves, buds, and capsules. Yellow or light brown blotches on upper leaf surface turn dark, with light gray mold on the underside. The fungus winters in old plant debris in soil. Remove and burn infected plants. Use clean seed.

Peronospora arthuri. **Downy Mildew** of godetia, clarkia, gaura, and evening primrose.

Peronospora destructor. **Onion Dowy Mildew**, **Blight**, general on onion, shallot, Vidalia sweet onion, and garlic. One of the more serious diseases of onion, reported in the United States in 1884. All varieties are susceptible, but red onions have some resistance. Reduction in yield may be as high as 75%. The first sign of onion mildew is the production of conidiophores with a purplish tinge a short distance back from tips of older leaves. Leaves turn yellow, wither, and break over; seedstalks may be infected. Onion mildew is sporadic, abundant in years of heavy rainfall. Spores, produced in great numbers in rain or when plants are wet with dew, lose vitality quickly when exposed to sun. Low temperature, optimum 50°F, favors infection. The fungus winters as mycelium in bulbs, in overwintering plants in mild areas, or as oospores in soil. Perennial onions in home gardens are considered an important source of primary inoculum, but oospores have been known to survive 25 years in soil.

Control. Calred is a resistant variety adapted to California. More onion seed is being produced in Idaho, where dry summers preclude mildew.

Peronospora dianthicola. **Carnation Downy Mildew**, common in California on seedlings. Leaves turn pale, curl downward; terminal growth is checked, and plants may die. There is a white growth on lower leaf surfaces.

Peronospora effusa. **Spinach Downy Mildew**, **Chard Blue Mold**, found wherever spinach and swiss chard are grown, absent some seasons, nearly destroying the crop in others. Large pale yellow spots grow together to cover all or part of the leaf; lower leaves are infected first, and then the blight is scattered through the plant. Gray to violet mold forms on underside of leaves;

sometimes the whole plant decays and dries. Initial infection comes from oospores in the soil; it requires humidity above 85% and a mean temperature between 45° and 65°F for a week. Secondary infection is from conidia. The fungus is an obligate parasite and does not live over on hosts other than spinach.

Control. Plant on well-drained, fertile ground; do not crowd; if overhead irrigation is used, water early on sunny days; practice a 2- to 3-year crop rotation. Resistant varieties such as Califlay and Texas Early Hybrid 7 are being introduced.

Peronospora farinosa (formerly *Peronospora schactii*). **Beet Downy Mildew**, on beet, sugar beet, and swiss chard. Inner leaves and seedstalks are stunted and killed, covered with violet down. The disease appears on the Pacific Coast during the fall rainy season. Oospores can survive in the soil several years.

Peronospora fragariae. **Strawberry Downy Mildew**.

Peronospora grisea, on veronica, a grayish mildew on underside of leaves.

Peronospora manshurica. **Soybean Downy Mildew**, general. Yellow-green foliage spots turn brown, with a grayish mold underneath; there may be premature defoliation. The pathogen winters as mycelium in seed and oospores in soil. There are at least three races.

Peronospora myosotidis. **Forget-Me-Not Downy Mildew**, also on lappula. Pale spots on upper surface of leaves, with downy growth underneath.

Peronospora oxybaphi, on sand verbena and four-o'clock.

Peronospora parasitica, on garden cress; **P. leptosperma**, on artemisia; **P. linariae**, on linaria; **P. lophanthi**, on agastache.

Peronospora parasitica. **Downy Mildew** of crucifers, general on cabbage, Chinese cabbage, broccoli, cauliflower, horseradish, radish, turnip, cress, peppergrass, also on sweet alyssum, arabis, arugula, stock, and hesperis. Chief damage is to cabbage seedlings or plants grown for seed. Leaf lesions are light green, then yellow, with downy mold on both sides of the leaf in the widening yellow zone but not in the dead, shrunken, gray or tan central portion. Secondary fungi often cover dead parts with a black sooty mold. Fleshy roots of turnips and radishes may be discolored internally. Warm days and cool nights favor the disease. The pathogen lives between crops in perennial plants or winter annuals. There are several strains of *P. parasitica*; one, often reported as *P. matthiolae*, blights stock in greenhouse and nursery. Leaves wilt; tender stems and flower parts are stunted and dwarfed.

Control. Avoid crowding plants; keep foliage dry. Spray cabbage seedlings; repeat two or three times a week until plants are set in field. Treat heading cabbage every 6 or 7 days beginning 1 to 3 weeks before harvest.

Peronospora pisi. **Pea Downy Mildew**. Water-soaked tissue and white growth appear on any aerial plant part. The mycelium winters in vetch stems, fruiting there in spring, and spores are disseminated back to peas. The disease is not important enough for control measures.

Peronospora potentillae. **Downy Mildew** of agrimony and mock strawberry.

Peronospora radii. **Downy Mildew** of Marguerite daisy, *Argyranthemum frutescens* (formerly *Chrysanthemum frutescens*).

Peronospora rubi. **Downy Mildew** of blackberry, dewberry, and black raspberry.

Peronospora rumicis. **Rhubard Downy Mildew**. A European disease reported from California on garden rhubarb. Fungus winters in rootstalks and grows up into new leaves.

Peronospora schactii (see *Peronospora farinosa*). **Beet Downy Mildew**, on beet, sugar beet, and swiss chard.

Peronospora sorghi (see *Peronosclerospora sorghi*). Downy mildew, on sweet corn.

Peronospora sparsa. **Rose Downy Mildew**, chiefly on roses under glass, rarely outdoors. Young foliage is spotted, leaves drop; flowers are delayed or unmarketable. Abundant spores are produced on undersurface of leaves. To control, keep humidity below 85% and daytime temperature relatively high.

Peronospora statices. **Downy Mildew** on statice.

Peronospora tabacina. **Blue Mold** of tobacco, **Downy Mildew**; also on eggplant, pepper, and tomato. This is a seedling disease that can be controlled by sprays on eggplant and pepper; it is unimportant on tomato.

Peronospora trifoliorum. **Downy Mildew** of lupine, and alfalfa.

Phytophthora

► Blights.

Phytophthora phaseoli. **Downy Mildew** of lima bean, most important in Middle and North Atlantic states, in periods of cool nights, heavy dews, and fairly warm days. Some seasons it takes 50 to 90% of the crop; in other

years it is of little consequence. The white downy mold is conspicuous on the pod, either in patches or covering it completely. The fungus grows through the pod wall into the bean, then the pod dries, turns black. On leaves the white mycelial weft appears sparingly, but veins are often twisted, purplish, or otherwise distorted. Young shoots and flowers are also attacked, bees and other insects carrying spores from diseased to healthy blossoms. The fungus fruits abundantly on pods, stems, and leaves; spores are splashed by rain.
Control. Use seed grown in the West where mildew is not present; plan a 2- to 3-year rotation. Copper dusts are satisfactory.

Plasmopara

Oomycetes, Peronosporales

Sporangiophores with monopodial branches, with obtuse tips, arising more or less at right angles; haustoria unbranched and knoblike; sporangia (conidia) small, hyaline, papillate, germinating sometimes by germ tubes but usually by swarm spores; oospores yellowish brown, outer wall wrinkled, sometimes reticulate, oogonial wall persistent but not fused with oospore wall (see Fig. 3.20).

Plasmopara acalyphae. **Acalypha Downy Mildew**.
Plasmopara geranii on geranium. **P. gonolobi** on gonolobus.
Plasmopara halstedii. **Downy Mildew** of bur-marigold, centaurea, erigeron, eupatorium, gnaphalium, goldenrod, hymenopappus, Jerusalem artichoke, ratibida, rudbeckia, senecio, silphium, verbesina, and vernonia. Zoospores germinate in soil moisture and invade seedlings via root hairs; mycelium moving up into stem and leaves causes early wilting and death. Older plants may not die but exhibit a light yellow mottling. Sporangiophores project through stomata on underside of leaves. The fungus winters in seed and as oospores in soil.
Plasmopara crustosa (formerly *Plasmopara nivea*). **Downy Mildew** of carrot, parsley, parsnip, and chervil. Yellow spots on upper surface of foliage and white mycelial wefts on under surface turn dark brown with age. The disease is relatively infrequent, important when plants are so crowded they cannot dry off quickly after rain or heavy dew. Control by spacing rows properly.
Plasmopara nivea (see *Plasmopara crustosa*). **Downy Mildew** of carrot, parsley, parsnip, and chervil.

Plasmopara pygmaea, on anemone, and hepatica. Fine white mildew covers underside of leaves; plants are distorted, stems aborted.

Plasmopara viburni. **Viburnum Downy Mildew**.

Plasmopara viticola. **Grape Downy Mildew**, general on grape, also on Virginia Creeper and Boston ivy. This is a native disease, endemic in eastern United States, first observed in 1834 on wild grapes. It appeared in France after 1870, imported with American stock resistant to the Phylloxera aphid, and in a few years had become as ruinous to the wine industry of Europe as the potato blight had been to Ireland. The efficacy of bordeaux was first discovered in connection with this mildew.

In this country downy mildew is most destructive on European varieties of grape. Pale yellow spots, varying in form but often nearly circular and somewhat transparent, appear on upper leaf surfaces, and a conspicuous white coating appears on lower surfaces. The spots turn brown with age; in dry weather the downy growth is scanty. Young canes, leafstocks, and tendrils may be infected; flowers may blight or rot; young fruits stop growing, turn dark, and dry with a copious grayish growth. Older fruits have a brown rot but lack the mildew effect. Fruits from diseased vines have less juice; bunches are very poorly filled.

Initial infection comes from a swarm spore stopping on the lower side of a leaf, putting out a germ tube and entering through a stoma. In 5 to 20 days the mycelium has spread through the leaf between cells, obtaining food through thin-walled, globular haustoria. The hyphae mass in compact cushions just beneath the stomata; under humid conditions a few grow out through the openings and develop into branched conidiophores (sporangiophores). Each has three to six main branches, and they branch again. The terminal branches end in two to four short, slender sterigmata, each of which produces a single multinucleate spore. With moisture, each nucleus with adjacent protoplasm is organized into a swarm spore, motile with two cilia. They swim around for a while, then settle down, absorb their cilia, and put out a germ tube. If they happen to be on the upper side of a leaf, nothing happens; if on the lower surface, the germ tube may reach a stoma and start an infection.

Toward the end of the growing season thick-walled resting spores, oospores, are produced in intercellular spaces of the infected leaves. These are set free in spring by disintegration of host tissue, are rain-splashed to other vines, and germinate by production of a short, unbranched hypha bearing a single large sporangium, to start the cycle anew.

Control. Copper sprays are effective. Apply bordeaux mixture immediately before and just after blooming; repeat 7 to 10 days later and possibly when fruit is half grown. Destroy fallen leaves by burning.

Pseudoperonospora

Oomycetes, Peronosporales

Like *Plasmopara* but with branches of sporangiophores forming more or less acute angles; tips more acute.

Pseudoperonospora celtidis. **Downy Mildew** of hackberry.

Pseudoperonospora cubensis. **Downy Mildew** of cucurbits, destructive to cucumber, muskmelon, and watermelon, particularly along the Atlantic seaboard and the Gulf Coast, occasional on gourd, pumpkin, and squash. The disease was first noted in 1889 in New Jersey, and in 1896 destroyed most of the cucumbers on Long Island. Irregular yellow spots appear on upper leaf surfaces, often on leaves nearest the center of the hill. The lesion is brown on the opposite side, covered with a purple growth in rain or dew. The whole leaf may wither and die, with the fruit dwarfed to nubbins and of poor flavor. The fungus does not live in the soil and is not prevalent in the North until July or August. It winters in greenhouses or comes up from the South by degrees. Sporangia are spread by wind and cucumber beetles. The disease is favored by high humidity, but temperatures need not be as cool as for other downy mildews.

Control. Resistant cucumbers are of rather poor quality. Cantaloupe varieties Texas Resistant No. 1 and Georgia 47 combine resistance to aphids with resistance to downy mildew.

Sclerospora

Oomycetes, Peronosporales

Oospore wall confluent with that of oogonium; sporangiophore typically stout with heavy branches clustered at apex; mycelium intercellular, with small, knoblike, unbranched haustoria; germination by germ tube or swarmspores. Common in moist tropic regions on corn, millet, sorghum, and sugar cane.

Sclerospora farlowii. **Downy Mildew** of Bermuda grass, in the Southwest. Short, black, dead areas prune off tips of leaves without serious damage to grass. Tissues are filled with thick-walled, hard oospores.

Sclerospora graminicola on cereals.

Sclerophthora macrospora (formerly *Sclerospor*a *macrospora*). **Downy Mildew** of oats, crazy top of corn, wheat, barley, St. Augustinegsrass, Kentucky bluegrass and wild grasses. Plants bunch owing to shortening of internodes.

FAIRY RINGS

Several species of mushrooms growing in circles in lawns and golf greens cause a condition known as fairy ring, rather common when the soil is quite moist and contains a superabundance of organic matter. Less commonly, some of these mushrooms are responsible for a poor condition of other herbaceous plants and of roses. The chief symptom in turf is the appearance of continuous or interrupted bands of darker green, due to the fungus mycelium breaking down organic matter into products easily assimilated by grass roots. Following the zone of stimulated growth there may be a zone of dying grass due to temporary exhaustion of nutrients, or to toxic substances from the mushroom mycelium, or because a layer has developed that is rather impervious to water. The green rings are more conspicuous on underfertilized lawns, and their presence can sometimes be masked by adequate fertilization. Breaking off the mushrooms, possibly spiking the sod, is all the control ordinarily recommended.

The following species are merely representative of the Basidiomycetes found in fairy rings. They are in the order Agaricales, family Agaricaceae.

Cyathus stercoreus (**Bird's Nest Fungus**). **Fairy Ring** on turf.

Lepiota morgani. On turf and also in rose greenhouses, causing poor growth. The caps are 2 to 12 inches across, white with scattered brown scales; flesh white; gills green when mature, spores green turning yellow, stem bulbous at base with a large ring (annulus). Poisonous, though other members of this genus, also causing fairy rings, are edible.

Marasmius oreades. Cap 2 inches or less, convex to plane, thin, tough, withering but not decaying; gills free from stem; spores white. Edible.

Psalliota (*Agaricus*) **campestris**. Cap 1 1/2 to 3 inches; white, silky, nearly flat; flesh white to pinkish; gills pink, then brown; spores brownish purple; stem white, with a ring when young. Edible.

Other Basidiomycetes found on lawns in moist weather include puffballs, which are very good eating when white and firm inside, and bird's nest fungi, which are tiny cups filled with "seed," resembling a nest of eggs.

Trechispora

Basidiomycetes, Aphyllophorales

Trechispora alnicola. **Blight**, **Fairy Ring** of Kentucky bluegrass.

FRUIT SPOTS

Many fruit blemishes are symptoms of rot diseases and are treated under Rots; others are due to physiological disturbances; a few others, limited to fruits and known primarily as fruit spots or specks, are included here.

Aureobasidium

Deuteromycetes

Yeast-like growth characteristics.

Aureobasidium pullulans. **Fruit Russet** on apple.

Cribropeltis

Deuteromycetes, Coelomycetes

Brown mycellium, branches profusely; black, irregularly circular pycnidia; simple, hyaline, clavate conidiophores; pale, oblong, straight or slightly curved conidia.

Cribropeltis citrullina. **Fly Speck** of watermelon fruits.

Zygophiala

► Blotches.

Zygophiala jamaicensis (*Schizothyrium pomi*). **Fly Speck** on apple.

Helminthosporium

► Blights.

Helminthosporium papulosum. **Black Pox** on apples and pears in eastern states. Fruit spots are small, sunken, dark, scattered in profusion over the surface. Blackish papules on bark are followed by a pitted or scaly condition. Spray with sulfur (except at high temperatures).

Microthyriella

Ascomycetes, Hemisphaeriales

Vegetative mycelium lacking; stromata with radial structure appearing as black superficial dots on leaves or stems.

Microthyriella rubi (see *Schizothyrium pevexiguum*). **Fly Speck** of pome fruits, general on apple, also on pear, quince, citrus fruits, banana, Japanese persimmon, plum, blackberry, raspberry, and grape.
Schizothyrium pevexiguum (formerly *Microthyriella rubi*). **Fly Speck** of pome fruits, general on apple, also on pear, quince, citrus fruits, banana, Japanese persimmon, plum, blackberry, raspberry, and grape. The pathogen has long been recorded as *Leptothyrium pomi*, but this is apparently a misconception. The anamorph state is *Zygophiala jamaicensis*, originally isolated from banana and recently reported as causing a greasy blotch of carnations. Flyspeck is often associated with sooty blotch on apples, but the two diseases are distinct. Flyspeck looks like its name, groups of 6 to 50 very small, slightly elevated, superficial black dots connected with very fine threads. Spots may extend entirely around blackberry canes and shoots.

Mycosphaerella

► Anthracnose.

Mycosphaerella pomi. **Brooks Fruit Spot**, **Phoma Fruit Spot**. Quince Blotch, of apple and quince, most prevalent in northeastern states. Spots appear on fruits in July or early August, deeper red on the colored face of apples, darker green on the lighter surface. They are irregular, slightly sunken, more abundant near the calyx end of the fruit, usually with centers flecked with black. The symptoms on quince are more of a blotch than a definite spot.

Rhodotorula

Rodotorula glutinis. **Fruit Russet** on apple.

GALLS

Galls are local swellings, hyperplastic enlargements of plant tissue due to stimulation from insects, bacteria, fungi, viruses, and occasionally physiological factors. Crown gall, a common and serious problem, is discussed under Bacterial Diseases. Cedar galls are treated under Rusts. See Black Knot for hypertrophy of plum branches.

Exobasidium

Basidiomycetes, Exobasidiales

Mycelium intercellular with branched haustoria entering host cells; basidia extend above the layer of epidermal cells much like the layer of asci in *Taphrina*; each basidium bears two to eight basidiospores. Species cause marked hypertrophy in the Ericaceae.

Exobasidium vaccinii. **Leaf Gall**, widespread on flame azalea.

Exobasidium burtii. **Leaf Gall**, **Yellow Leaf Spot** on azalea and rhododendron.

Exobasidium camelliae. **Camellia Leaf Gall** on camellia in the Southeast, more common on sasanqua than on japonica. Symptoms are a striking enlargement and thickening of leaves and a thickening of stems of new shoots. Diseased leaves are four or more times as wide and long as normal leaves, very thick and succulent. Color of the upper surface is nearly normal, but the underside is white with a thin membrane that cracks and peels back in strips or patches exposing the spore-bearing layer. There is seldom more than one diseased shoot on a stem, and not many on the whole bush; so the disease does not cause serious damage.

Control. Handpicking of affected parts, searching carefully for diseased leaves at base of new growth, removing them before spores are formed, keeps sporadic infection at a minimum. Spraying with a low-lime bordeaux may be effective but is seldom necessary.

Exobasidium oxycocci. **Cranberry Rose Bloom**, **Shoot Hypertrophy** on cranberry, and manzanita. The disease appears in cranberry bogs soon after water is removed in spring. Bud infection results in abnormal lateral shoots with enlarged, swollen, pink or light rose distorted leaves that somewhat resemble flowers. Excessive water supply promotes the disease. Remove water early in spring. If necessary, spray with bordeaux mixture.

Exobasidium rhododendri. **Rhododendron Leaf Gall**. Large vesicular galls, especially on *Rhododendron catawbiense* and *R. maximum*.

Exobasidium symploci. **Bud Gall** on sweetleaf.

Exobasidium uvae-ursi. **Shoot Hypertrophy** of bearberry.

Exobasidium vaccinii. **Azalea Leaf Gall**, **Red Leaf Spot**, **Shoot Hypertrophy** of andromeda, arbutus (*A. menziesii*), bearberry, blueberry (fruit green spot), box sandmyrtle, chamaedaphne, cranberry, farkleberry, huckleberry, ledum, leucothoë, manzanita, and rhododendron. On azaleas and other ornamentals the galls are bladder-shaped enlargements of all or part of a leaf, sometimes a flower bud (see Fig. 3.21). They are white or pink, soft and succulent when young, brown and hard with age. This is seldom a serious disease but in wet seasons, particularly in the South, and in shaded gardens, the number of galls may become rather alarming. On cranberries and blueberries the gall is a small, round, red blister in the leaf, with spores packed in a dense layer on the underside. The fungus is systemic in blueberries, fruiting on the leaves in June and July.

Control. Handpick and destroy galls as they appear. Spraying is seldom required for cranberries and other fruits.

Exobasidium vaccinii-uliginosi. **Shoot and Leaf Gall**, **Witches' Broom** of rhododendron, manzanita, and mountain heath. An excessive number of twigs is formed on infected branches. Leaves are yellowish white covered with a dense mealy fungus growth. The mycelium penetrates the whole plant so that it is wiser to remove the shrub than to attempt remedial measures.

Fusarium

► Rots.

Fusarium decemcellulare (Teleomorph, *Nectria rigidiuscula*). **Gall** on midge.

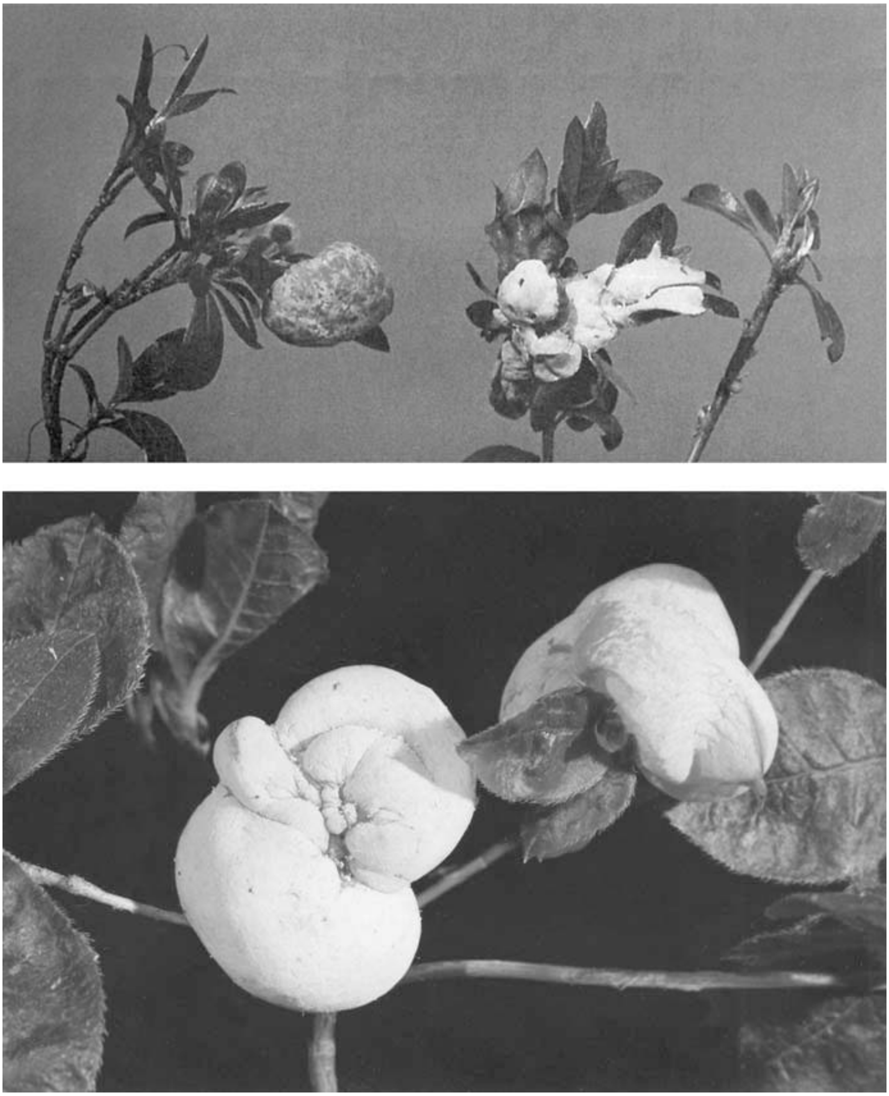


Figure 3.21 Azalea Leaf Gall

Kutilakesa

Deuteromycetes, Hyphomycetes

Sporodochia erumpent, pale olive-green, cushion-shaped; similar to Kutilakesopsis but differs by having larger two-celled conidia; teleomorph state is *Nectriella*.

Kutilakesa pironii. **Stem and Leaf Gall**, **Cankers** on croton, zebra plant, and *Clorodendron*.

Nocardia

Actinomycetales

Related to bacteria with mycelial filaments breaking up into rod forms.

Nocardia vaccinii. **Blueberry Bud-Proliferating Gall**, first observed in Maryland in 1944, described as a new species in 1952. Galls, similar to crown gall, are formed at the soil line. Abnormal buds abort at an early stage or grow into weak shoots, 1 to 6 inches high, forming a witches' broom effect.

Phoma, Phomopsis

► Blights.

Phoma sp. or **Phomopsis** sp. **Stem Gall** on winter jasmine, privet, forsythia, and rose, at scattered locations. Both pathogens have been reported causing roundish, rather rough stem enlargements on ornamentals. It has not been determined whether more than one fungus is involved.

Plasmopara

► Downy Mildew.

Plasmopara halstedii. **Basal Gall** on sunflower.

Protomyces

Archiascomycetes, Taphrinales

Protomyces gravidus. **Stem gall** on ragweed.
Protomyces macrosporus. **Leaf gall** on hedge parsley (*Torilis* sp.).

Sphaeropsis

► Cankers.

Sphaeropsis tumefaciens. **Canker** and **Gall** on *Carissa*.

Synchytrium

Chytridiomycetes, Chytridiales

Mycelium lacking; thallus converted into a soros with a membrane, at maturity functioning in entirety as a resting sporangium or divided to form many sporangia in a common membrane; zoospores with one cillum at posterior end. Various species cause excrescences on leaves and fruit; potato wart.

Synchytrium anemones. **Leaf Gall**, **Flower Spot** of anemone and thalictrum. Flowers are spotted, distorted, dwarfed, and may fall. Red spots are formed on leaves and stems.

Synchytrium aureum. **Red Leaf Gall**, **False Rust** on many plants, 130 species in widely separated genera, including calypha, artemisia, clintonia, delphinium, geum, golden-glow, marsh-marigold, and viola. Pick off and burn affected parts.

Synchytrium endobioticum. **Potato Wart**, **Black Wart** of potatoes, a warty hypertrophy of tubers. A European disease wart was found in 1918 in backyard gardens in mining towns of Pennsylvania, Maryland, and West Virginia. Diseased tubers had apparently been brought in by immigrants. A strict quarantine was placed on infested districts, and there has been no spread to commercial potato fields. The disease shows as prominent outgrowths or warts originating in the eyes, varying from the size of a pea to that of the tuber itself. Numerous yellow sporangia are released into the soil by decay of the malformed tissue. The disease, which may affect other species of *Solanum*, is spread by contaminated soil or infected tubers. Buds and adventitious shoots of tomato are infected below the soil line.

Control. By 1953 potato wart had been eradicated from more than half of the 1112 infested gardens in Pennsylvania. The plan called for applying copper sulfate the first year, keeping the land clean and cultivated, applying lime the next year, growing vegetables the third year, and going back to potatoes the fourth year to test results.

Synchytrium vaccinii. **Red Leaf Gall** on cranberry, azalea, chamaedaphne, gaultheria, and ledum, from New Jersey northward. On cranberry the disease appears just before blossoms open. Buds, flowers and young leaves are covered with small, red, somewhat globular galls about the size of birdshot; affected shoots bear no fruit. The disease is erratic in appearance but is most frequent in bogs that have excessive or uneven water supply.

Synchytrium sp. **Stem Gall** on castor bean, in Texas. Small red galls on stems, petioles, and leaves of seedlings.

LEAF BLISTER AND LEAF CURL DISEASES

A single genus, *Taphrina*, is responsible for most of the hyperplastic (overgrowth) deformities known as leaf blister, leaf curl, or, occasionally, as pockets.

Taphrina

Archiascomycetes, Taphrinales

Parasitic on vascular plants, causing hypertrophy. Asci in a single palisade layer, not formed in a fruiting body; hyphal cells become thin-walled chlamydospores; on germination the inner spore protrudes from the host and is cut off by a septum to form an eight-spored ascus, which may become many-spored by budding or the ascospores.

Taphrina spp. **Maple Leaf Blister**. Leaves after expanding in spring show dark spots, shrivel, and fall. The disease may be locally epidemic; it is more common in shaded locations.

Taphrina aceris. **Western Maple Leaf Blister**.

Taphrina aesculi. **Leaf Blister** of California buckeye; yellow turning to dull red; witches' brooms formed.

Taphrina australis. **American Hornbean Leaf Curl**.

Taphrina caerulescens. **Oak Leaf Blister** on various oak species, with red oak particularly susceptible but often defoliating and sometimes killing water, willow, laurel, and live oaks in the South. Blisters start on young partially grown leaves as gray depressed areas on the undersurface, convex and yellow on the upper surface. Individual blisters are 1/4 to 1/2 inch across but often become confluent, causing the leaf to curl. Ascospores are borne on the surface of the blistered area. The disease is most serious in a cool wet spring. *Control*. A single dormant eradicant spray, before the buds swell, controls the disease; later sprays are ineffective.

Taphrina carnea. **Birch Red Leaf Blister**.

Taphrina castanopsidis. **California Chinquapin Leaf Blister**.

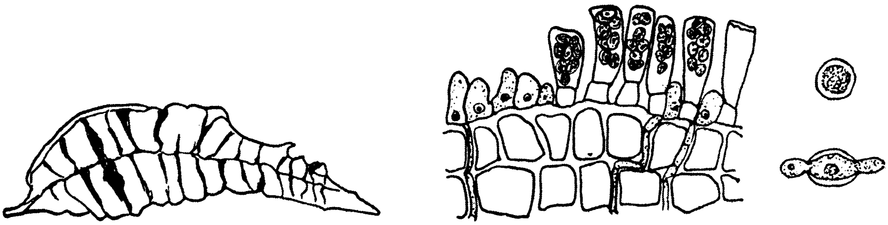


Figure 3.22 Peach Leaf Curl; deformed leaf; palisade layer of asci formed on curled portion; germinating spore

Taphrina communis. **Plum Pockets**, common on American plums; **T. pruni**, on European species, not in United States; **T. prunisubcordata**, in western United States. Leaves, shoots and fruits become puffy and enlarged into reddish or white swollen bladders. Fruits are sometimes ten times the size of normal plums. Most garden plums are of foreign origin and not susceptible to the American species of *Taphrina*. Bordeaux mixture applied in spring before flower buds open gives satisfactory control.

Taphrina coryli. **Hazelnut Leaf Blister**.

Taphrina deformans. **Peach Leaf Curl**, general on peach, also on nectarine and almond but not on apricot. This is an old disease, known in the United States for well over a century but not quite so important since 1900, when a control was worked out. Young leaves are arched and reddened, or paler than normal as they emerge from the bud, then much curled, puckered, and distorted, greatly increased in thickness (Fig. 3.22). Any portion or the entire leaf may be curled, and one or all leaves from a bud. The leaves often look as if a gathering string had been run along the midvein and pulled tight. Leaves may drop, lowering vitality of tree, with partial or total failure to set fruit, and increasing chances of winter injury. Young fruits may be distorted or cracked. Defoliation for several seasons kills tree outright.

The fungus has no summer stage, and the asci are formed not in a fruiting body but in a layer over infected surfaces, giving them a silvery sheen. Before leaves fall, ascospores are discharged from this layer, and land on bark or twigs and bud scales, there to germinate by budding into yeastlike spores, which remain viable over winter, sometimes for 2 years. In spring they are washed by rain to opening leaf buds.

Control. One spray during the dormant season gives effective control. This is best applied just before the buds swell, but can be done any time after leaf fall in autumn when the temperature is above freezing. Applications after the buds swell have little effect.

Taphrina faulliana. **Leaf Blister** of Christmas fern; **T. filicina**, on sensitive fern; **T. struthiopteridis**, on ostrich fern.

Taphrina flava. **Yellow Leaf Blister** of gray and paper birches in northeastern states.

Taphrina japonica (*T. macrophylla*). **Leaf Curl** on red alder. Young leaves are enlarged to several times normal size and curled. They dry up after ascospore discharge, and a new crop of healthy leaves is formed.

Taphrina populina. **Leaf Blister**, **Yellow** on poplar.

Taphrina populina. **Poplar Yellow Leaf Blister**. Conspicuous blisters, small to large, an inch or more in diameter, are brilliant yellow on the concave side when the asci are fully developed; later the color changes to brown.

Taphrina robinsoniana, **T. occidentalis**, **T. alni**. **Catkin Hypertrophy** of alder. Scales of catkins enlarge and project as reddish curled tongues covered with a white glistening layer. Infection can be reduced with a lime sulfur spray.

Taphrina sacchari. **Maple Brown Leaf Blister**.

Taphrina ulmi. **Elm Leaf Blister**. Very small blisters on elm leaves. Dusting nursery trees with sulfur has helped.

Taphrina weisneri. **Cherry Witches' Broom**, **Leaf Curl** on wild and cultivated cherries, **T. flavorubra**, on sand cherry; **T. flectans**, on western wild cherry; **T. farlowii**, leaf curl and fruit pockets on eastern wild cherry; **T. confusa**, on chokecherry; **T. thomasii**, witches' broom of cherry-laurel in California.

LEAF SCORCH

According to the dictionary scorching means to heat so as to change color and texture without consuming. Sometimes leaves are literally scorched in summer heat, and sometimes symptoms caused by fungi resemble those of a heat scorch. This section includes some of the latter.

Ceratocystis

► Cankers.

Ceratocystis paradoxa. **Black Scorch**, **Bud Scorch**, **Heart Rot** of coconut, Canary, Washington, and Guadaloupe palms, also causing a pineapple disease in the tropics. The most striking symptom is a black, irregular, necrotic condition of the leaf stalk. The tissues look as if they had been burned, whence the name black scorch. Furled pinnae of leaf fronds show pale yellow spots with broad margins that later converge and turn black; infection spreads rapidly, and in severe cases the heart leaves dry up. The heart rot discolors trunk tissues and rots the pithy material between cells. Infection is through wounds during periods of relatively high humidity, or through roots, or sometimes through uninjured fruit strands, petioles, or pinnae. Palms with vitality lowered, as when the normal crown of leaves has been reduced but the water supply to the leaves is not reduced, are most susceptible.

Control. Destruction of infected parts seems to be the chief control measure. It is easier to bury than to burn palm trunks.

Curvularia

► Blights.

Curvularia sp. **Leaf Scorch** on pecan.

Diplocarpon

► Blackspot.

Diplocarpon earlianum. **Strawberry Leaf Scorch**, general where strawberries are grown but more prevalent in the South. Dark purplish spots about 1/4 inch in diameter are scattered profusely over upper surface of leaves in all stages of development. Later the spots enlarge to scorch wide areas of the leaf, and black fruiting bodies give a "tar spot" appearance. Scorch spots always lack the white centers so characteristic of Mycosphaerella leaf spot on strawberry. Lesions are found on petioles, stolons, and fruit stalks as well as leaves. If the fruit stems are girdled, flowers or young fruits die. Rarely the disease appears on green berries as a superficial red or brown discoloration and flecking. Spores, produced in quantity in acervuli on lesions, are distributed by birds, insects, and pickers on tools and clothing. The fungus winters in old leaves. Teleomorph and anamorph states are both produced in spring, and repeated infections occur throughout the summer in moist weather.

Control. Remove all old leaves when setting plants in spring. Spray with bordeaux mixture at 10-day intervals, starting in January in Louisiana, late February in North Carolina. Fairly resistant varieties include Catskill, Midland, Fairfax, Howard 17, Blakemore, Southland.

Epicoccum

► Leaf Spots.

Epicoccum sp. **Leaf Scorch** on pecan.

Fusarium

► Rots.

Fusarium sp. **Leaf Scorch** on pecan.

Hendersonia

Deuteromycetes; Coelomycetes

Pycnidia dark, separate, globose, ostiolate, immersed then usually erumpent; conidia dark, several-celled, elongate to fusoid; saprophytic or parasitic.
Hendersonia opuntiae. **Scorch**, **Sunscald**, common and serious on prickly pear cactus (*Opuntia*). Segments turn reddish brown and die; centers are grayish brown and cracked.

Pestalotia

► Blights.

Pestalotia sp. **Leaf Scorch** on pecan.

Pseudopezicula

Ascomycetes, Helotiales

Hyaline, gelatinous apothecia containing paraphyses and 20 - 80 asci; asci contain 4 reniform, binucleate ascospores; five-spored asci rarely observed.

Pseudopezicula tetraspora. **Leaf Scorch** of grapevines.

Septoria

► Blights.

Septoria azaleae. **Azalea Leaf Scorch**, **Leaf Spot**. Small, yellowish, round spots enlarge irregularly, turn reddish brown, with dark brown centers. Leaves fall prematurely; black fruiting bodies are produced in fallen leaves. The disease is most severe in greenhouses in fall and winter and under high humidity.

Stagonospora

Deuteromycetes, Coelomycetes

Pycnidia dark, separate, superficial, or erumpent, globose, ostiolate; conidiophores short; conidia hyaline, typically with three or more cells, cylindrical to elliptical; parasitic or saprophytic.

Stagonospora curtisii. **Narcissus Leaf Scorch**, **Red Blotch** of Amaryllis, **Red Leaf Spot**, **Red Fire Disease**, also on crinum, eucharis, hymenocallis, leucojum, nerine, sternbergia, vallota, and zephyranthes.

Leaf tips of narcissus are blighted for 2 or 3 inches as in frost injury and separated off from healthy basal portions of leaves by a definite margin or yellow area. Spores formed in pycnidia in the dead area furnish inoculum for secondary infection, which consists of lesions in lower portions of leaves, minute water-soaked or yellowish spots becoming raised, scabby, and reddish brown. Flower stalks may be spotted; brown spots appear on petals. Bulbs suffer loss in weight due to killing of foliage a month or two before normal dying down. All types may be infected but the most susceptible varieties are in the Leedsii and Polyanthus groups. The fungus was described on narcissus in 1878 but was not considered a threat to it, nor was it known to be connected with amaryllis red blotch before 1929.

On amaryllis or hippeastrum red spots are formed on leaves, flower stems, and petals. On foliage the spots are bright red to purplish, small at first but often increasing to 2 inches. Leaf or flower stalks are bent or deformed at the point of attack. This disease should not be confused with “red disease” caused by mites. The spores are variable in size and number of cells, one to six. They are embedded in a gelatinous matrix and are disseminated in rain. The fungus apparently winters in or on bulbs, infecting new leaves as they grow out in spring.

Control. Treat suspected narcissus bulbs before planting. Control secondary infection in the field with bordeaux mixture. Discard seriously diseased amaryllis bulbs; remove infected leaves and bulb scales; avoid syringing and heavy watering.

LEAF SPOTS

Leaf spots are the most prevalent of plant diseases, so common we seldom notice them, and rightly so, for if we should attempt to control all the miscellaneous leaf spots that appear in a small suburban garden in a single season, we would quickly go mad. A typical leaf spot is a rather definitely delimited necrotic lesion, often with a brown, sometimes white, center and a darker margin. When the spots are so numerous they grow together to form large dead areas, the disease becomes a blight, or perhaps a blotch, or scorch. Certain types of lesions are called anthracnose, spot anthracnose, blackspot. All of these have been segregated out in their different sections. What is left is a very large collection of names.

The genus *Septoria*, for instance, has about 1000 species, *Mycosphaerella* 500, *Cercospora* 400, chiefly identified by the hosts on which they appear. *Cercospora beticola* is so named because it causes a leaf spot of beet, *C. apii* for its celery host. Species recorded in this country as causing a definite disease are listed under their respective hosts. They are not repeated here unless the leaf spot is of some importance or there is some useful information that can be added to the name.

Most leaf spot diseases flourish in wet seasons. A comparative few may be important enough to call for control measures other than general sanitation. Adequate protection usually means several applications of fungicides, and the cost of spraying trees and shrubs must be balanced against the expected damage. Calling in a tree expert with high-pressure apparatus is often an expensive proposition. If the budget is limited, it is more important to have an elm sprayed for elm leaf beetles, which cause defoliation every season, than for elm black spot, which may be serious in only one year out of three or four. When it comes to rose blackspot (no relation to elm black spot), weekly protection with a fungicide is necessary, but to save labor it can be combined with insecticides.

Actinothyrium

Deuteromycetes, Coelomycetes

Pycnidia superficial, globose, with a more or less fimbriate shield; spores filiform, hyaline.

Actinopelte dryina (see *Tubakia dryina*). On oak.
Actinothyrium gloeosporioides (see *Tubakia dryina*). On oak. **Leaf Spot** on sassafras.
Tubakia dryina (formerly *Actinopelte dryina*). On oak. Very small dark spots between veins. Conspicuous in midsummer but not serious.
Tubakia dryina (formerly *Actinothyrium gloeosporioides*). **Leaf Spot** on sassafras.

Alternaria

► Blights.

Alternaria alternata. **Leaf Spot** of *Calathea* spp.
Alternaria alternata (formerly *Alternaria fasciculata*). **Leaf Spot** on rose-acacia and asclepiodora.
Alternaria alternata (formerly *Alternaria tenuis*). **Leaf Spot** of magnolia, hibiscus, clarkia, and many ornamental and other hosts. The fungus is a general saprophyte and an occasional weak parasite. It discolors beet, chard, and spinach seed.
Alternaria angustiovoidea. **Leaf Spot** and **Blight** of leafy spurge.
Alternaria brassicae (with large spores) and **A. brassicicola** (with small spores). **Black Leaf Spot** of crucifers, cabbage, Chinese cabbage, collards, turnip, garden cress, mustard greens, radish, and horseradish; **Head Browning** leaf and pod spot of cauliflower; **Damping-off**, **Wire-stem** of seedlings.
Seedlings are subject to pre- or post-emergence damping-off, with dark brown to black sunken spots on cotyledons, narrow dark spots on stems, followed by wire-stem, a blackening toward the base. Leaf spots are small, circular, yellowish, enlarging in concentric circles with a sooty black color from the spores. In storage the spots unite to form a moldy growth over the entire leaf. On seed pods, spots are purplish at first, later brown; in moist

weather entire pods may be infected. Cauliflower infection is a browning of the head, starting at the margin of an individual flower or cluster. Spores are blown, splashed by tools, spread on feet of men and animals. Seed bears spores externally, mycelium internally. Wounds are not necessary for infection.

Control. Hot water treatment of seed, 122°F for 30 minutes, is fairly effective. Use long rotation for cauliflower, avoiding all other crucifers in intermediate years.

Alternaria brassicicola. **Leaf Spot** on Thlaspi.

Alternaria brassicicola (formerly *Alternaria oleracea*). **Cabbage Leaf Spot**, occasional on crucifers. Has been confused with *A. brassicicola*.

Alternaria catalpae. **Catalpa Leaf Spot**, widespread in rainy seasons. Small, water-soaked spots, up to 1/4 inch, appear over the leaf; they turn brown and sometimes drop out leaving shot holes; there is more or less defoliation. The fungus is sometimes secondary following bacterial infection or midge infestation. Rake up and burn fallen leaves.

Alternaria chrysanthemi (see *Alternaria leucanthemi*). **Leaf Spot** on shasta daisy, and Canada thistle.

Alternaria citri. **Cherry Leaf Spot**, occasional, more often a rot of citrus fruits. ► Rots.

Alternaria fasciculata (see *Alternaria alternata*). **Leaf Spot** on rose-acacia and asclepiodora.

Alternaria leucanthemi (formerly *Alternaria chrysanthemi*). **Leaf Spot** on shasta daisy, and Canada thistle.

Alternaria longipes. **Brown Spot** of tobacco, including ornamental flowering tobacco. Small spots on lower leaves rapidly enlarge and turn brown. The fungus winters on old stalks, which should be removed and burned.

Alternaria oleracea (see *Alternaria brassicicola*). **Cabbage Leaf Spot**, occasional on crucifers.

Alternaria panax. **Leaf Spot** of schefflera, *Dizygotheca*, and *Tupidanthurs*.

Alternaria passiflorae. **Brown Spot** of passion flower. Minute brown leaf spots, enlarging to an inch across are concentrically zoned with various shades of brown. Dark green water-soaked spots on fruit turn brown; the fruit shrivels, but the spots stay firm.

Alternaria polypodii. **Fern Leaf Spot**. Brown, circular to ovate, concentrically zonate spots are formed along margins of fronds. Chains of spores are spread by syringing or air currents. Keep foliage dry; remove and burn diseased leaves.

Alternaria raphani. **Radish Leaf Spot**. Yellow spots with black sporulation, often with centers dropping out. Also occurs on turnip.
Alternaria sonchi. **Leaf Spot** of lettuce, escarole, endive, and chicory.
Alternaria tagetica. **Leaf Spot** of marigold.
Alternaria tenuis (see *Alternaria alternata*). **Leaf Spot** of magnolia, hibiscus, clarkia, and many ornamental and other hosts.
Alternaria tenuissima. **Leaf Spot** on blueberry.
Alternaria tenuissima (formerly *Alternaria tomato*). **Nailhead Spot** of tomato, a leaf, stem, and fruit spot. On leaves and stems the disease is much like early blight (see *A. solani* under Blights) with small dark brown spots with yellow margins. But on fruit the disease is quite different. Very small tan spots, 1/16 to 1/8 inch in diameter, become slightly sunken, with grayish brown centers and darker margins. Spores produced abundantly on fruit and foliage are spread by winds and splashing rain. Treat seed and spray as for early blight. Varieties Marglobe, Pritchard, Glovel, and Break O'Day are quite resistant to nailhead spot. The same fungus causes ghost spot of apple.
Alternaria tomato (see *Alternaria tenuissima*). **Nailhead Spot** of tomato, a leaf, stem, and fruit spot.
Alternaria sp. **Leaf Spot** of schefflera, and umbrella tree.

Amerosporium

Deuteromycetes, Coelomycetes

Pycnidia superficial, discoid to cupulate, hairy; spores one-celled, hyaline.

Amerosporium trichellum (see *Colletotrichum trichellum*). **Leaf Spot** and **Stem Spot** on English ivy.
Colletotrichum trichellum (formerly *Amerosporium trichellum*). **Leaf Spot** and **Stem Spot** on English ivy. In some cases stems are girdled, causing collapse and death.

Annellophora

Deuteromycetes, Hyphomycetes

Conidiophores brown, simple, slender, elongating by successive proliferations through conidial scars; conidia brown, multiseptate, obclavate to fusoid.

Annellophora phoenicis. **Leaf Spot** of date palm.

Aristastoma

Deuteromycetes, Coelomycetes

Pycnidia brown, globose, erumpent, separate, with dark brown setae near ostiole; conodiophores short, simple; conida hyaline, several-celled.

Aristastoma oeconomicum. **Zonate Leaf Spot** of cowpea, kidney bean.
Aristastoma sp. **Leaf Spot** on desert-rose.

Ascochyta

► Blights.

Ascochyta abelmoschi (possibly identical with *A. phaseolorum*). **Leaf Spot**, **Pod Spot**, **Stem Spot** of okra. Dark, small, water-soaked spots slowly enlarge, turn brown, with many large black pycnidia in concentric rings in dead tissue. Young okra pods are severely infected, and the mycelium grows into the seed.
Ascochyta althaeina (see *Phoma exigna*). **Leaf Spot** of hollyhock, rose-mallow.
Ascochyta armoraciae. **Leaf Spot** of horse-radish.
Ascochyta aspidistrae. **Aspidistra Leaf Spot**. Large, irregular pale spots on leaves.
Ascochyta asteris (see *Phoma exigna*). **Leaf Spot** of China aster.
Ascochyta boltshauseri. (see *Stagonosporopsis hortensis*). **Leaf Spot**, **Pod Spot** of beans, on snap, kidney, lima, and scarlet runner beans, reported in Oregon.
Aschochyta. **Leaf Spot** on big bluestem, little bluestem (both species of *Andropogon* and on indiangrass.
Ascochyta cheiranthi. **Leaf and Stem Spot** of wallflower. Grayish spots up to 1/2 inch long, may girdle stems. Leaf spots are circular to elongate, brown with darker brown margins. Dark pycnidia contain hyaline, two-celled spores. Leaves wilt and fall; potted plants may be infected. Keep greenhouse on the dry side.
Ascochyta clematidina. **Clematis Leaf** and **Stem Spot**, widespread. On out-door plants stems are infected near the ground and are often girdled, upper portions dying back. Spores for initial infection probably come from

pycnidia on stumps of old stems. Leaf spots are more common in greenhouses, small, water-soaked, then buff with reddish margins. Remove and destroy infected leaves and stems.

Ascochyta compositarum. **Leaf Spot** on aster, eupatorium, silphium, and sunflower.

Ascochyta cornicola. **Dogwood Leaf Spot**.

Ascochyta cypripedii. **Cypripedium Leaf Spot**, reported on orchid from Wisconsin. Leaf lesions are narrow, brownish, with a dark brown border.

Ascochyta juglandis. **Walnut Ring Spot**. Very small, round, brown leaf spots between veins, ringed with targetlike ridges. The disease is unimportant in trees sprayed for walnut blight.

Ascochyta lycopersici (**Didymella lycopersici**) (see *Phoma lycopersici*) **Leaf Spot**, **Ascochyta Blight** of tomato, eggplant, and potato.

Ascochyta phaseolorum (see *Phoma exigua*). **Leaf Spot** of snap beans.

Ascochyta pisi. **Leaf Spot**, **Pod Spot** of pea. General, but rare in the Northwest. One of three species causing the disease complex known as Ascochyta blight (also see Blights). Foliage spots are circular to irregular, pinhead size to 1/2 inch. Stem lesions, at nodes or base, are brown to purplish black. Brown pycnidia exude spore tendrils in wet weather.

Phoma exigua (formerly *Ascochyta althaeina*). **Leaf Spot** of hollyhock, rose-mallow.

Phoma exigua (formerly *Ascochyta asteris*). **Leaf Spot** of China aster. Spray foliage with bordeaux mixture.

Phoma exigua (formerly *Ascochyta phaseolorum*). **Leaf Spot** of snap beans. Recent isolation and inoculation studies indicate that the Ascochyta leaf blights of hollyhock, okra, pepper, eggplant, and tomato are all caused by strains of the bean pathogen.

Phoma lycopersici (formerly *Ascochyta lycopersici* (*Didymella lycopersici*)). **Leaf Spot**, **Ascochyta Blight** of tomato, eggplant, and potato. Brown spots with concentric rings are formed on leaves and stems, sometimes cankers at base of young stems. Black pustules in center of spots discharge spore tendrils in wet weather. The fungus winters in old plant refuse, is a weak parasite, and is ordinarily too unimportant for control measures.

Stagonosporopsis hortensis (formerly *Ascochyta boltschauseri*). **Leaf Spot**, **Pod Spot** of beans, on snap, kidney, lima, and scarlet runner beans, reported in Oregon. Spots on leaves and pods are dark to drab, zonate; light to dark brown pycnidia are numerous.

Asteroma

Deuteromycetes, Coelomycetes

Pycnidia globose with a radiate subicle, a compact, crustlike growth of mycelium underneath; without an ostiole; spores hyaline, one-celled.

Asteroma garretianum. **Black Spot** on primrose.
Asteroma solidaginis. **Black Spot**, **Black Scurf** on goldenrod.
Asteroma tenerrimum. **Black Spot** on erythronium.

Asteromella (Stictochlorella)

Deuteromycetes, Coelomycetes

Pycnidia smooth, with ostiole, densely gregarious in asteroma-like spots; spores hyaline, one-celled.

Asteromella lupini. **Leaf Spot** on lupine.

Botrytis

► Blights.

Botrytis fabae. **Chocolate Leaf Spot** on vetch.

Calonectria

See Cylindrocladium under Blights.
Calonectria colhounii. **Leaf Spot** on sentry palm.
Calonectria crotalariae. **Leaf Spot** on sentry palm.
Calonectria theae. **Leaf Spot** on sentry palm.

Cephaleuros

One of the green algae, possessing chlorophyll but not differentiated into root, stem, and leaves; forming motile spores in sporangia.

Cephaleuros virescens. **Algal Spot**, **Red Leaf Spot**, **Green Scurf** in the far South or in greenhouses on acacia, albizzia, ardisia, avocado, bixa, bischofia, camellia, camphor-tree, cinnamon-tree, citrus, grevillea, guava, jasmine, jujube, loquat, magnolia, mango, pecan, Japanese persimmon, privet, rhododendron, viburnum.

On some hosts this is a disease of twigs and branches, which may be girdled and stunted, covered with reddish brown hairlike fruiting bodies. On magnolia leaves velvety, reddish brown to orange, cushiony patches are formed, but in the absence of sporangia (tiny globular heads on fine, dense reddish hairs) the leaf spots remain greenish brown. Occasionally citrus fruits as well as leaves are attacked.

The sporangia formed on the fine hairs germinate in moist weather, producing zoospores that enter through stomata and form mycelium-like chains of algal cells in host tissue. On twigs the alga invades outer cortical tissue, which may swell abnormally, crack, and afford entrance to injurious fungi. Weakened trees are most susceptible, and disease spread is most rapid in periods of frequent and abundant rains. Twigs may die, and there may be reduced yield of citrus fruit.

Control. Improve draining and other growing conditions; citrus trees sprayed regularly with copper seldom have algal trouble. If it gets started, follow cleanup pruning with a bordeaux mixture spray in December or January. Repeat with bordeaux at start of rainy season or when red stage of the alga is first seen, and spray again 1 month later. A neutral copper may substitute for bordeaux for the last two applications. The copper kills beneficial insects parasitic on scales, but the oil controls the scale insects.

Cephalosporium

Deuteromycetes, Hyphomycetes

Conidiophores slender or swollen, simple; conidia hyaline, one-celled, produced successively at the tip and collecting in a slime drop, produced endogenously in some species; saprophytic or parasitic, some species causing vascular wilts of trees.

Cephalosporium apii. **Celery Brown Spot**, a new disease first reported from Colorado in 1943, later from New York and Ohio. Irregular light tan or reddish brown shallow lesions are formed on celery leaf stalks, petioles, and leaflets. They may unite to make a scurfy brown streak up the inside of the stalk and may develop transverse cracks. Utah and Pascal varieties are most susceptible.

Cephalosporium cinnamomeum. **Leaf Spot** of nephthytis and syngonium. Small circular to irregular spots, reddish brown with pale yellow borders enlarge, with centers becoming gray and papery. In severe cases leaves turn yellow and die. Pick off infected leaves. Maintain low temperature and humidity.

Cephalosporium dieffenbachiae. **Dieffenbachia Leaf Spot**. Small red lesions with dark borders appear on young leaves. Spots sometimes run together, and the whole leaf turns yellow and dies. Infection is often through mealybug wounds. Avoid promiscuous syringing; keep temperature and humidity low; control mealybugs, and ants that transport them.

Cercospora

► Blights.

Cercospora abeliae. **Abelia Leaf Spot**, reported from Louisiana. Irregular purple to brown spots; defoliation.

Cercospora abelmoschi (see *Pseudocercospora abelmoschi*). **Leaf Spot** on okra, hibiscus.

Cercospora albo-maculans (Syn. Cercosporella brassicae) (see *Pseudocercospora capsellae*). **White Spot** of turnip, Chinese cabbage, mustard, and other crucifers, common in the Southeast.

Cercospora althaeina. **Leaf Spot** of hollyhock and abutilon. Spots circular, angular or irregular, 1.5 mm, olivaceous to grayish brown, with the dead tissue falling out. The fungus winters in old plant parts.

Cercospora angulata. **Leaf Spot** on philadelphus, currant, flowering currant, and gooseberry. Circular to angular spots, dingy gray centers, dark purple to nearly black margins.

Cercospora aquilegiae. **Columbine Leaf Spot**, reported from Kansas, Wisconsin, Oregon. Spots circular to elliptical, reddish brown to nearly black; fruiting is on both sides of the leaf.

Cercospora arachidicola (*Mycosphaerella arachidicola*, Teleomorph). **Peanut Early Leaf Spot**. Spots light tan aging to reddish or dark brown with a yellow halo, often confluent. Conidiophores on both sides of the leaf, emerging from stomata or breaking through epidermal cells. Conidia colorless to pale yellow or olive, with 5 to 12 cells. Control with sulfur-copper dust.

Cercospora armoraciae. **Horse-Radish Leaf Spot**. Tan to dingy gray lesions with yellow-brown margin; often slightly zonate.

Cercospora beticola. **Cercospora Leaf Spot** of beet, general on garden and sugar beets, also on swiss chard, spinach. Brown flecks with reddish purple borders become conspicuous spots with ash-gray centers and purple margins. The brittle central tissue often drops out, leaving ragged holes. The spots usually remain small but are often so numerous that foliage is killed. If successive crops of leaves are lost, the crown of the beet root is elongated and roughened. Leaf spotting is of little direct importance except in chard, where foliage is used for greens. The beet root yield is reduced.

The grayish color of the spots is due to long, thin, septate conidia produced on conidiophores protruded through stomata in fascicles or groups, coming from a knotted mass of mycelium resembling a sclerotium. Conidia are spread by rain, wind, tools, and insects. Infection is through stomata; disease spread is most rapid under conditions of high humidity that keep stomata open. Hot weather favors the disease.

Control. Crop rotation is highly important. In a small garden pick off the first spotted leaves.

Cercospora bougainvilleae (see *Cercosporidium bougainvilleae*). **Leaf Spot** first seen in Florida in 1962 and now the most important pathogen of this host.

Cercospora brunkii. **Geranium Leaf Spot**, mostly in the South. Spots are circular, light reddish brown with dark brown borders, sometimes coalescing to kill entire leaf.

Cercospora calendulae. **Calendula Leaf Spot**. Spots run together to blight and kill leaves; plants may be destroyed early in the season. Spores enter through stomata of plants more than a month old.

Cercospora cannabina (see *Pseudocercospora cannabina*). **Leaf Curl and Wilt** on hemp.

Cercospora cannabis. **Leaf Spot** on hemp.

Cercospora capsici. **Pepper Leaf Spot**, **Stem-end Rot**, common in the Southeast, serious in rainy seasons. Spots 1/7 to 1 inch in diameter are first water-soaked then white with dark brown margins. Leaves turn yellow and drop. The fungus grows through the pedicel into fruit, causing a rot of the stem end. Loss of foliage exposes the fruit to sunscald. Spray or dust with copper.

Cercospora circumscissa (*Mycosphaerella cerasella*, Teleomorph). **Leaf Spot**, **Shot Hole** of apricot, plum, cherry, cherry-laurel, oriental cherry, and chokecherry. Dead spots are somewhat larger than those caused by other shot-hole fungi, but the damage is not serious.

Cercospora citrullina. **Leaf Spot** of watermelon, muskmelon, and other cucurbits. Spots are small, circular, black with grayish centers, occurring first on leaves in center of watermelon hills. On cucumber, muskmelon, and squash the spots are large and ochre-gray. Defoliation of vines causes reduction in fruit size, but the disease is not considered important. Clean up diseased vines; use a 2- or 3-year rotation; spray or dust as for bacterial wilt.

Cercospora concors (see *Mycovellosiella concors*). **Potato Leaf Spot**, **Leaf Blotch**.

Cercospora cornicola. **Dogwood Leaf Spot**, in the Gulf states, often with *Septoria florida*. Spots irregular without definite borders.

Cercospora fusca (see *Sirosporium diffusum*). **Pecan Brown Leaf Spot**, prevalent throughout the pecan belt but minor, serious only with high rainfall and in neglected orchards where trees lack vigor.

Cercospora lathyrina. **Leaf Spot** on pea and sweet pea, in southern states and north to New Jersey and Missouri. Angular to elongate spots have dirty gray centers with a black line border.

Cercospora lythracearum. **Leaf Spot** on crape-myrtle, in Texas. Spots circular, pale brown to gray with a greenish fringe or yellow halo.

Cercospora magnoliae (see *Cercosporidium magnoliae*). (*Mycosphaerella milleri*, Telleomorph). On magnolia in South.

Cercospora melongenae. **Eggplant Leaf Spot**, more common in tropical areas. Yellow lesions change to large brown areas with concentric rings.

Cercospora nandinae. **Nandina Leaf Spot**, one of the few diseases of this usually healthy shrub. Red blotches appear on upper leaf surface with centers of older spots almost black. There is a scant sooty fruiting layer on the undersurface. Reported from Alabama and North Carolina.

Cercospora personata (*Mycosphaerella berkeleyii*, Teleomorph) (see *Phaeoisariopsis personata*). **Peanut Leaf Spot**, general on peanut.

Cercospora piaropi. **Leaf Spot** on water-hyacinths.

Cercospora pittospori. **Pittosporum Leaf Spot**, reported from Mississippi, Florida, Louisiana, and Texas. Spots small, angular, yellow to dull brown, fruiting in fawn-colored effuse patches on lower surface.

Cercospora puderi (see *Pseudocercospora puderi*). **Leaf Spot** on rose, reported from Georgia and Texas.

Cercospora resedae. **Leaf Spot**, **Blight** of mignonette, a rapid disease killing much of the foliage. Numerous small circular spots, pale yellow with reddish brown borders, run together, discoloring the entire leaf. Spores are spread by wind and rain; lower leaves are most affected.

Cercospora rhododendri (see *Pseudocercospora handelii*). **Rhododendron Leaf Spot**.

Cercospora richardiaecola. **Leaf Spot** on calla lily, sometimes injurious. Spots circular, brown, tan, or gray. Avoid syringing; keep plants well spaced; ventilate greenhouse.

Cercospora rosicola (*Mycosphaerella rosicola*, Teleomorph). **Cercospora Spot** of rose, wherever roses are grown but more important in the South. Spots are circular, 1 to 4 mm, but coalescing to irregular areas, purplish or reddish brown with pale brown, tan, or gray centers. Perithecia are formed in fallen leaves.

Cercospora smilacis. **Smilax Leaf Spot**. Spots are more or less circular up to 1/4 inch, dark purplish red, centers fading with age but margins remaining definite and dark.

Cercospora sojina. **Frog-Eye Disease** of soybean. Typical frog-eye spots are formed on leaves and elongated reddish lesions on stems, changing to brown, gray, or nearly black with age. Pods of late varieties may be infected. The fungus winters on diseased leaves and stems. Seed treatment is not effective; crop rotation is necessary. Early varieties often escape injury. There is a wide difference in varietal susceptibility.

Cercospora symplocarpi. **Leaf Spot** on snowberry, coralberry, and wolfberry. Very small circular to angular spots, uniformly brown or with tan centers and brown margins.

Cercospora sp. **Leaf Spot** on kalanchoë.

Cercospora zebrina. **Leaf and Stem Spot** on bean, cowpea, groundnut, peanut, birdsfoot trefoil and Lespedeza. **Leaf Spot** on clovers

Cercosporidium bougainvilleae (formerly *Cercospora bougainvilleae*). **Leaf Spot** first seen in Florida in 1962 and now the most important pathogen of this host. Lesions are 1 to 5 mm, circular, depressed, with brown or tan centers, reddish brown margins and a diffuse chlorotic area.

Cercosporidium magnoliae (formerly *Cercospora magnoliae*). (*Mycosphaerella milleri*, Telleomorph). On magnolia in South. Leaf spots are small, angular, dark, with narrow yellow halo.

Mycovellosiella concors (formerly *Cercospora concors*). **Potato Leaf Spot**, **Leaf Blotch**. Spots none to large irregular brown areas. Fruiting on undersurface; conidiophores very pale; conidia almost hyaline.

Phaeoisariopsis personata (formerly *Cercospora personata* (*Mycosphaerella berkeleyii*, Teleomorph)). **Peanut Leaf Spot**, general on peanut. Spots are circular, 1 to 7 mm, but may coalesce; dark brown to black, often with a yellow halo. Conidiophores on both sides of the leaf, more numerous on the lower, are arranged concentrically in tufts; the epidermis is ruptured. Spores are pale brown to olivaceous, one- to eight-septate. In wet seasons vines may be nearly defoliated. Primary infections come from ascospores on overwintered peanut leaves. Sulfur dust with 3.5% copper is recommended; apply every 10 to 14 days.

Pseudocercospora abelmoschi (formerly *Cercospora abelmoschi*). **Leaf Spot** on okra, hibiscus. Spots indistinct, but a sooty fruiting of spores on under leaf surface.

Pseudocercospora cannabina (formerly *Cercospora cannabina*). **Leaf Curl and Wilt** on hemp.

Pseudocercospora capsellae (formerly *Cercospora albo-maculans* (Syn. *Cercosporella brassicae*)). **White Spot** of turnip, Chinese cabbage, mustard, and other crucifers, common in the Southeast. Small, pale, circular slightly sunken spots; may coalesce.

Pseudocercospora handelii (formerly *Cercospora rhododendri*). **Rhododendron Leaf Spot**. Angular dark brown spots with grayish down in center. Control seldom necessary.

Pseudocercospora puderi (formerly *Cercospora puderi*). **Leaf Spot** on rose, reported from Georgia and Texas. Spots are circular, to 5 mm, with dingy gray centers, brown or reddish brown margins. Fruiting is chiefly on the upper surface in dense fascicles of short conidia.

Sirosporium diffusum (formerly *Cercospora fusca*). **Pecan Brown Leaf Spot**, prevalent throughout the pecan belt but minor, serious only with high rainfall and in neglected orchards where trees lack vigor. Spots are circular to irregular, reddish brown, often with grayish concentric zones. The fungus winters in old spots on leaves. In Florida the disease appears first in June or July on mature leaves and may cause premature defoliation in October. Stuart variety is particularly susceptible; others are more resistant. Control with one application of bordeaux mixture between May 15 and June 15.

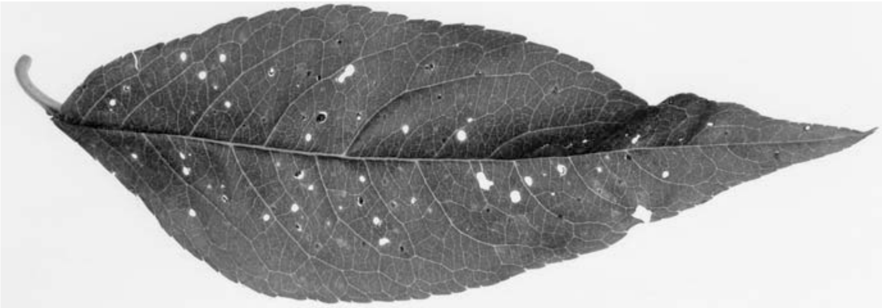


Figure 3.23 Shot-Hole on *Prunus* sp

Cercosporella

Deuteromycetes, Coelomycetes

Conidiophores hyaline, bearing conidia apically or on short branches; conidia hyaline, cylindrical to filiform with several cells (see Figs. 3.23 and 3.24); like *Cercospora* except for light conidiophores; parasitic.

Cercosporella brassicae (see *Pseudocercosporella capsellae*). **Leaf Spot** of cabbage, turnip, mustard, on West Coast.
Pseudocercosporella capsellae (formerly *Cercosporella brassicae*). **Leaf Spot** of cabbage, turnip, mustard, on West Coast. Lesions on cabbage are black, those on turnip and mustard gray with tan margins.

Cercosporidum

Cercosporidium personata (see *Phaeoisariopsis personata*). **Leaf Spot** on peanut.
Phaeoisariopsis personata (formerly *Cercosporidium personata*). **Leaf Spot** on peanut.

Ciborinia

► Blights.

Ciborinia whetzelii (Syn. *Sclerotinia whetzelii*). **Black Leaf Spot** of poplar, **Ink Spot**, from New England States to the Rocky Mountains on

aspen, black poplar, and other species. Saucerlike, thin black sclerotia are formed in leaves, fall to the ground, and produce apothecia in spring. There is often considerable defoliation, and small trees may be killed.
Ciborinia seaveri (*Sclerotinia bifrons*). **Ink Spot**, in western states, producing apothecia on ground under cottonwoods and poplars but pathogenic state confused.

Cladosporium

► Blotch Diseases.

Cladosporium colocasiae. **Leaf Spot** on elephants ear.
Cladosporium echinulatum. **Leaf Spot** on carnation.
Cladosporium epiphyllum. **Leaf Spot** on locust.
Cladosporium oxysporum. **Leaf Spot** on tomato

Blumeriella (Coccomyces)

Ascomycetes, Discomycetes

Blumeriella jaapii (formerly *Coccomyces hiemalis* and *Higginisia hiemalis*). **Cherry Leaf Spot**, **Blight**, **Shoot Hole**, general on sweet and sour cherries, the most common and destructive leaf disease of cherries. Leaf spots are circular, first purplish, then brown, falling out to give the shot-hole effect (see Fig. 3.24). If lesions are numerous, the leaves turn yellow and fall by midsummer, this premature defoliation reducing next season's harvest. The fungus winters in fallen leaves, producing disc-shaped apothecia for primary infection. Secondary infection comes from conidia, formed in whitish masses on the spots in moist weather, more numerous on the undersurface. New infection continues through the summer after harvest. Defoliation prior to ripening reduces size and quality of fruit and exposes it to sunscald. Some seasons shoots, spurs, and branches are killed, followed by a light crop the next year. Thousands of sour cherry trees have been killed.
Control. An eradicant spray of a dinitro compound, such as Elgetol, applied to the ground in early spring, reduces the amount of primary inoculum, but summer sprays are also necessary. On sour cherry this may mean a spray at petal fall, another 10 days later, two sprays in June, and another just after

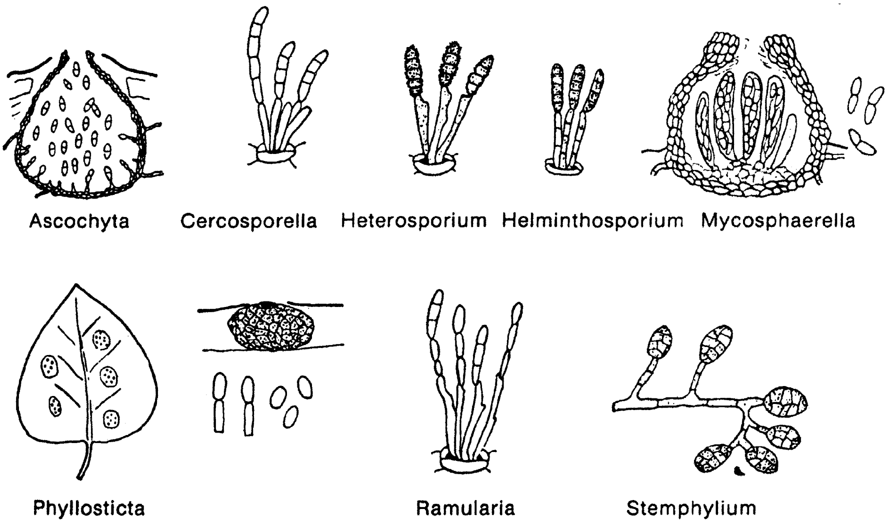


Figure 3.24 Some Leaf-Spot Fungi. *Ascochyta*, hyaline, two-celled conidia in pycnidium; *Cercosporella*, hyaline, septate spores on condiophores emerging from a stoma; *Cladosporium* (formerly *Heterosporium*), spiny, dark, septate spores; *Helmonthosporium*, smooth, dark, septate spores; *Mycosphaerella*, two-celled hyaline ascospores in a perithecium; *Phyllosticta*, hyaline, one-celled conidia in pycnidia formed in spots on leaves; *Ramularia*, hyaline spores, becoming septate, formed successively on conidiophores; *Stemphylium*, colored muriform spores borne free on mycelium

fruit is picked, with more applications, especially on nursery trees, needed in some seasons. Consult your state experiment station for suitable materials and schedule for your area.

Blumeriella jaapii (formerly *Coccomyces lutescens*). **Leaf Spot**, **Shot Hole** on cherry-laurel, black cherry, and chokecherry. Similar to the disease caused by *C. hiemalis*.

Blumeriella jaapii (formerly *Coccomyces prunophorae*). **Leaf Spot**, **Shot Hole** on garden plum and apricot. Reddish to brown spots, dark blue initially, produce pinkish spore masses on underside of leaves in wet weather. The shot-hole effect from dropping out of dead tissue may be very prominent and accompanied by heavy fruit drop. Spray when shucks are off young fruit, 2 or 3 weeks later, and before fruit ripens, with lime sulfur, or with wettable sulfur.

Blumeriella kerriae (formerly *Coccomyces kerriae* and *Higginisia kerriae*). **Kerria Leaf Spot**, **Twig Blight**, widespread on kerris from eastern states to Texas. Leaves have small, round to angular, light brown or reddish brown spots with darker borders. When spots are numerous, leaves turn yellow and die. Similar lesions on young stems may run together into extended cankers, the bark splitting to show black pycnidia, from which ooze out masses of long, white, curved spores. The fungus winters in old dead leaves. Spraying with bordeaux mixture may help.

Coccomyces hiemalis and **Higginisia hiemalis** (see *Blumeriella jaapii*). **Cherry Leaf Spot**, **Blight**, **Shoot Hole**, general on sweet and sour cherries, the most common and destructive leaf disease of cherries.

Coccomyces kerriae and **Higginisia kerriae** (see *Blumeriella kerriae*) **Kerria Leaf Spot**, **Twig Blight**, widespread on kerria from eastern states to Texas.

Coccomyces lutescens (see *Blumeriella jaapii*). **Leaf Spot**, **Shot Hole** on cherry-laurel, black cherry, and chokecherry.

Coccomyces prunophorae (see *Blumeriella jaapii*). **Leaf Spot**, **Shot Hole** on garden plum and apricot.

Colletotrichum

► Anthracnose.

Colletotrichum acutatum. **Fruit Spot**, **Crown and Petiole Spot** on strawberry.

Colletotrichum coccodes. **Leaf Spot** and **Slight Blight** of velvetleaf.

Colletotrichum dematium f. sp. **truncata**. **Leaf Spot** and **Stem Canker** of *Stylosanthes* spp.

Colletotrichum elastica (see *Colletotrichum gloeosporioides*). **Leaf Spot** on fig (*Fiscus carica*). **Leaf Spot** of basil, flowering dogwood, cyclamen, jasmine, passion flower, leaf and stem spot of calendula and dwarf mistletoe; on many other hosts as anthracnose.

Colletotrichum gloeosporioides (formerly *Colletotrichum elastica*). **Leaf Spot** on fig (*Fiscus carica*). **Leaf Spot** of basil, flowering dogwood, cyclamen, jasmine, passion flower, leaf and stem spot of calendula and dwarf mistletoe; on many other hosts as anthracnose.

Coniothyrium

► Cankers.

Coniothyrium concentricum (see *Microsphaeropsis concentrica*). **Leaf Spot** of century plant and yucca.

Coniothyrium hellebori. **Black Spot** of Christmas rose. Large, irregular, dark brown to black spots on both sides of leaves, often running together with concentric zonation; many leaves turn yellow prematurely and die; plants are weakened and fail to mature the normal number of leaves. Stems may be cankered, shrivel, and fall over, with wilting of unopened flower buds. Open petals sometimes have black spots. In wet weather in spring and fall the disease can spread through an entire planting in 2 or 3 days, but continuous moisture is necessary for infection. Spray with bordeaux mixture.

Coniothyrium pyrina. **Leaf Spot**, **Fruit Spot** of apple, pear.

Microsphaeropsis concentrica (formerly *Coniothyrium concentricum*). **Leaf Spot** of century plant and yucca. Spots are zoned, light grayish brown, an inch or more in diameter, with concentric rings of tiny black pycnidia. Large portions of leaves may be destroyed. Remove and burn diseased leaves.

Corynespora

Deuteromycetes, Hyphomycetes

Hyphae and conidia both dark.

Corynespora cassiicola (Syn. *Helminthosporium vignicola*). **Soy Bean Target Spot**, also on cowpea, tomato, poinsettia, vinca, and privet; general in South. Circular to irregular, reddish brown leaf spots, pin point to 1/4 inch, often zonate and surrounded by yellow-green halos. Fruit necrotic pitting and freckles are also found on infected fruit. Dark brown spots on petioles, pods, and seed. Variety Ogden is moderately resistant. The same fungus causes reddish purple spots on azalea, hydrangea and leaf spots on lipstick vine, and on weeping fig and leaf spot on thyme.

Cristulariella

Deuteromycetes, Moniliales, Moniliaceae

Sterile hyphae decumbent; fertile hyphae hyaline; ascending in a branched head with conidia at tips of intermediate branches; spores globose, hyaline, one-celled.

Cristulariella depraedans. **Leaf Spot** on sugar and other maples. Spots gray, definite or confluent.

Cristulariella moricola. **Zonate Leaf Spot** on Halesia. **Leaf Spot** on hibiscus and tomato.

Cristulariella moricola (Telemorph, *Grovesinia pyramidalis*). **Leaf Spot** on maple, tree-of-heaven, apple, bean, blueberry, cherry, dogwood, hibiscus, sycamore, tung tree, viburnum, walnut, black walnut, beggar-ticks, trumpet vine, Mexican tea, dayflower, blue waxweed, tick clover, mistflower, white snakeroot, morning glory, Indian tobacco, blue cardinal-flower, beefsteak plant, poke, smart weed, false buckwheat, yellow dock, prickly mallow, goldenrod, catbird grape, nectarine, grape, maple, serviceberry and boxelder. Spots yellow-gray with definite margins.

Cryptomycina

Ascomycetes, Rhytismatales

Apothecium splitting irregularly into lobes, hyphal layer thin; spores hyaline, one-celled.

Cryptomycina pteridis. **Tar Spot** of fern, bracken. Spots are usually on lower surface and between veins; leaves may roll.

Cryptostictis

► Blights.

Cryptostictis arbuti (see *Seimatosporium arbuti*). **Leaf Spot** on *Arbutus menziesii, Manzanita*, ledum.

Seimatosporium arbuti (formerly *Cryptostictis arbuti*). **Leaf Spot** on *Arbutus menziesii, Manzanita*, ledum.

Cycloconium

Deuteromycetes, Hyphomycetes

Mycelium coiled, spores small, dark, two-celled; scarcely different from short hyphae.

Cycloconium oleaginum. **Olive Leaf Spot**, **Peacock Spot**, **Ring Spot**. Blackish, more or less concentric rings on leaves, especially those weakened or old.

Cylindrocladium

Deuteromycetes, Hyphomycetes

Conidiophores repeatedly dichotomously or trichotomously branched, each terminating in two or three phialides (cells developing spores); conidia hyaline, with two or more cells, cylindrical, borne singly; parasitic or saprophytic.

Cylindrocladium avesiculatum. **Leaf Spot** and **Twig Dieback** on holly, and *Leucothoë* sp.
Cylindrocladium colhounii. **Leaf Spot** on bottle-brush (Callistemon).
Cylindrocladium clavatum. **Leaf Spot** on bottle-brush (Callistemon).
Cylindrocladium pteridis. **Leaf Spot**, **Leaf Blight** of Washington palm. Numerous small dark brown spots with light margins are somewhat disfiguring.
Cylindrocladium pteridis. **Fern Leaf Spot**, **Leaf Blotch**. Reddish brown lesions run together to cover large areas. Pick off and burn infected fronds.

Cylindrosporium

Deuteromycetes, Coelomycetes

Acervuli subepidermal, white or pale; conidiophores short, simple; conidia hyaline, filiform, straight or curved, one-celled or septate; parasitic on leaves.

Cylindrosporium betulae. **Brown Leaf Spot** of Birch. Sometimes serious enough to defoliate but not often present on ornamental trees.
Cylindrosporium chrysanthemi. **Chrysanthemum Leaf Spot**. Spots are dark brown with yellowish margins, increasing to take in the whole leaf, which hangs down. Similar to more common Septoria leaf spot.
Cylindrosporium clematidinis. **Clematis Leaf Spot**. Reddish brown spots on lower leaves, which may drop. Dusting with sulfur has been suggested.
Cylindrosporium salicinum. **Willow Leaf Spot**. Sometimes causing defoliation; can be controlled with bordeaux mixture if necessary.
Cylindrosporium sp. **Leaf Spot** on spirea, recorded from a Kansas nursery. Light yellow lesions turn dark brown, with masses of yellow conidia on underside.

Cytospora

► Cankers.

Cytospora sp. **Leaf Spot** on mulberry.

Dactylaria

Dactylaria higginsii. **Leaf Spot** on nutsedge.

Dichotomophthoropsis

Deuteromycetes, Hyphomycetes

Dichotomophthoropsis nymphaearum. **Leaf Spot** on water-lily, and water shield.

Didymaria

Deuteromycetes, Hyphomycetes

Conidiophores simple, arising from leaf surface in loose groups; conidia hyaline, two-celled, ovate-oblong, borne singly; parasitic on leaves.

Didymaria didyma (see *Ramularia didyma*). **Leaf Spot** on anemone. Angular brown spots.
Ramularia didyma (formerly *Didymaria didyma*). **Leaf Spot** on anemone. Angular brown spots.

Didymellina

Acomycetes, Sphaeriales, Mycosphaerellaceae

Perithecia separate, innate or finally erumpent, not beaked; spores two-celled, hyaline.

Didymellina macrospora (*Heterosporium iridis, H. gracilis*) (see *Mycosphaerella macrospora*, Anamorph). **Irish Leaf Spot**, **Blotch**, **Fire** on both bulbous and rhizomatous iris.
Didymellina ornithogali (*Heterosporium ornithogali*) (see *Mycosphaerella ornithogali*). **Leaf Spot** on star-of-bethlehem.

Didymellina poecilospora. A weak parasite sometimes causing black discoloration of iris foliage.

Mycosphaerella macrospora (formerly *Didymellina macrospora*; *Heterosporium iridis, H. gracilis*, Anamorph). **Irish Leaf Spot**, **Blotch**, **Fire** on both bulbous and rhizomatous iris. The spotting is conspicuous toward the end of the season but is not too serious in a normally dry season. Usually the spots are confined to the upper half of leaves, but if plants are crowded and shaded and the summer is wet, the spotting appears earlier, covers more of the leaf, and is more damaging.

Spots are dark brown at first, surrounded by a water-soaked and then yellowing region; they enlarge into rather oval lesions, up to 1/2 inch long, with a red-brown border (Fig. 3.25). Flower buds and stems of bulbous iris may be attacked. Tufts of olive conidia turn the centers grayish, the spores being produced in abundance and splashed by rain to neighboring leaves. Infection is through stomata or directly through the epidermis. The fungus winters as mycelium in old leaves, and in spring produces a fresh crop of conidia or perithecia of the *Didymellina* stage. Soils deficient in lime apparently favor

Figure 3.25 Iris Leaf Spot

the disease. Repeated spotting reduces bloom and, after a number of years, may kill plants.

Control. It is often sufficient to remove and burn all old leaves at the end of the season; shearing back spotted leaves in midsummer is helpful. If the disease is regularly a problem, spray with bordeaux mixture, starting when fans are 6 to 8 inches high and repeating at 10- to 14-day intervals.

Mycosphaerella ornithogali (formerly *Didymellina ornithogali*; *Heterosporium ornithogali*, Anamorph). **Leaf Spot** on star-of-bethlehem. Occasional sooty spots on leaves, with foliage blackened and killed in severe infections.

Didymosporium

Deuteromycetes, Coelomycetes

Conidia are slime-spores in acervuli; dark, two-celled.

Didymosporium arbuticola. **Leaf Spot** on *Arbutus menziesii*.

Dilophospora

Deuteromycetes, Coelomycetes

Pycnidia distinct in a stroma; conidia very long, filiform, with bristlelike hairs at each end. Usually found on cereals and sometimes with the wheat nematode, causing a disease called twist.

Dilophospora geranii (see *Pestalozziella subsessilis*). **Leaf Spot** on native geranium.

Pestalozziella subsessilis (formerly *Dilophospora geranii*). **Leaf Spot** on native geranium.

Diplodina

Deuteromycetes, Coelomycetes

Pycnidia black, separate, immersed or erumpent, globose or flattened, ostiolate; conidiophores simple, slender; conidia hyaline, two-celled, ovoid or ellipsoid; parasitic or saprophytic. Similar to *Ascochyta* but not produced in spots.

Diplodia rhododendri (see *Encoeliopsis rhododendron*). **Leaf Spot** on rhododendron.

Encoeliopsis rhododendron (formerly *Diplodia rhododendri*). **Leaf Spot** on rhododendron.

Diplotheca (Stevensea)

Ascomycetes, Myriangiales

Asci born singly in locules at various levels in a massive stroma; spores dark, several-celled.

Diplotheca wrightii. **Black Spot**, **Charcoal Spot** of Opuntia cacti in Florida and Texas uncommon in the North. Dark spots, 1/4 inch or more in diameter, are surrounded by a ring of fruiting bodies.

Dothichiza

► Cankers.

Dothichiza caroliniana. **Leaf Spot**, **Double Spot** of blueberry, found only on *Vaccinium australis* in North Carolina, but there causing extensive defoliation. Leaf spots are small, circular, with brown centers and a dark brown ring, but in late summer infection spreads to a secondary necrotic area around the original spot, giving the common name of double spot. Black pycnidia are formed sparsely in the spots. All varieties of high bush blueberries are somewhat susceptible, but Cabot, Dixie, Pioneer, and Rancocas are most damaged.

Ectostroma

Deuteromycetes, Hyphomycetes

Black stromata formed in leaves and stems.

Ectostroma liriodendri. **Tar Spot**, widespread in tulip-trees but perhaps secondary after insect injury.

Epicoccum

Deuteromycetes, Hyphomycetes

Sporodochia dark, rather cushion-shaped; conidiophores compact or loose, rather short; conidia dark, with one or more cells, globose; mostly saprophytic.

Epicoccum asterinum (see *Epicoccum nigrum*). **Leaf Spot** of yucca; *E. neglectum*, on royal palm; *E. nigrum*, on *Magnolia grandiflora*; *E. purpurascens*, on amaryllis.
Epicoccum nigrum (formerly *Epicoccum asterinum*). **Leaf Spot** of yucca; *E. neglectum*, on royal palm; *E. nigrum*, on *Magnolia grandiflora*; *E. purpurascens*, on amaryllis. All of these may be secondary infections. *E. neglectum* and *E. purpurascens* are also synonyms of *E. nigrum*.

Exosporium

Deuteromycetes, Hyphomycetes

Conidia on subglobose to convex sporodochia; spores dark, with two to several cells, somewhat club-shaped.

Discogloeum concentricum (formerly *Exosporium concentricum*). **Leaf Spot** on euonymus and ligustrum (privet) in the South.
Exosporium concentricum (see *Discogloeum concentricum*). **Leaf Spot** on euonymus and ligustrum (privet) in the South.

Fusicladium

Deuteromycetes, Hyphomycetes

Mycelium forming a stroma under cuticle of host; conidiophores dark, short; conidia dark, two-celled, produced successively as pushed-out ends of new growing tips. Parasitic on higher plants, causing scab as well as leaf spots.

Fusicladium pisicola. **Black Leaf** of peas, first reported in Utah in 1921, causing trouble with canning peas. Spots start as small, irregular whitish areas on undersurface of leaflets and stipules, but they darken to gray or black from the closely packed layer of dark conidia. The disease is not very important.
Fusicladium robiniae (see *Phaeoisariopsis robiniae*). **Leaf Spot**, **Seedling Leaf Blight** of black locust.
Phaeoisariopsis robiniae (formerly *Fusicladium robiniae*). **Leaf Spot**, **Seedling Leaf Blight** of black locust. Spots are small, with light centers and dark margins. There is frequently defoliation of seedlings, sometimes stunting and death.

Gibbago

Deuteromycetes, Hyphomycetes

Gibbago trianthemae. **Leaf Spot** of horse purslane; a new genus and species, recently described (1986), with potential for bioherbicide activity.

Gloeocercospora

Deuteromycetes, Hyphomycetes

Sporodochia formed on surface of host above stomata from hyphae emerging through openings; conidiophores hyaline, simple or branched; conidia hyaline, elongate to filiform, one- to many-septate, straight or curved, in a slimy matrix.

Gloeocercospora inconspicua. **Leaf Spot** of highbush and rabbit-eye blueberry. Circular to angular brownish spots on leaves, with sporodochia more frequent on upper surface. These are flat discs when dry, glistening globules when wet, containing curved, septate conidia.
Gloeocercospora sorghi. **Copper Spot** of turf. (► *Ramulispora sorghi*).

Gloeosporium

► Anthracnose.

Asteroma inconspicuum (formerly *Gloeosporium inconspicuum*). **Elm Leaf Spot**, **Twig Blight**, **Anthracnose** on American and English elms. Subcircular brown spots with darker margins and centers are visible on upper and lower leaf surfaces.
Cryptocline betularum (formerly *Gloeosporium betularum*). **Leaf Spot**, **Anthracnose** of river birch. Spots are more or less circular, 1/8 inch across, brownish with pale centers and yellow margins.
Gloeosporium betularum (see *Cryptocline betularum*). **Leaf Spot**, **Anthracnose** of river birch.
Gloeosporium inconspicuum (see *Asteroma inconspicuum*). **Elm Leaf Spot**, **Twig Blight**, **Anthracnose** on American and English elms.
Gloeosporium mezerei (see *Marssonina daphnes*). **Leaf Spot** on daphne.
Gloeosporium rhododendri. **Leaf Spot** on rhododendron, tulip-tree.

Gloeosporium ulmicola. **Elm Leaf Spot**. Elongated spots on midribs, veins, and margins, visible on both leaf surfaces.

Marssonina daphnes (formerly *Gloeosporium mezerei*). **Leaf Spot** on daphne. Small brown spots on both sides of leaves.

Glomerella

► Anthracnose.

Glomerella cingulata. **Leaf Spot**, widespread on queen palm, dracaena, and maranta. Sobralia blight of orchids. Dark discoloration starts at tip of leaves and advances toward base.

Glomerella cingulata. **Leaf Spot** on apple, aucuba, wampi, and croton. See under Anthracnose for this fungus on many other hosts.

Glomerella sp. **Black Spot** of Vanda orchids.

Gnomonia

► Anthracnose.

Gnomonia comari. **Leaf Spot/Blotch** and **Fruit Rot** of strawberry.

Gnomonia fragariae. **Leaf Spot**, **Leaf Blotch** of strawberry. Often associated with *Dendrophoma* causing leaf blight, but not connected.

Gnomonia nerviseda (formerly *Gnomonia caryae* var. *pecanae*). **Pecan Liver Spot**. Dark brown circular spots, mostly along midribs on underside of leaves, appear in May and June. In autumn the color changes to cinnamon brown, and dark fruiting bodies appear; there may be premature defoliation. Spray in May with bordeaux mixture.

Pecan Vein Spot. Lesions resemble pecan scab on veins or leaf stems; sometimes a narrow brown lesion extends nearly the length of a midrib. Defoliation may be moderate or severe. Stuart variety is especially susceptible. Spray with bordeaux mixture just before and just after pollination; repeat 3 to 4 weeks later.

Gnomonia ulmea, Anamorph, *Gloeosporium ulmeum* (see *Stegophora ulmea*). **Elm Black Spot**, **Black Leaf Spot** of Elm, general on American, English, and Chinese elms.

Gnomonia caryae var. **pecanae** (see *Gnomonia nerviseda*). **Pecan Liver Spot**.

Stegophora ulmea (formerly *Gnomonia ulmea*, Anamorph, *Gloeosporium ulmeum*). **Elm Black Spot**, **Black Leaf Spot** of Elm, general on American, English, and Chinese elms. Spots on leaves are small but conspicuous, shining coal black, and slightly raised. Leaves may turn yellow and drop, with severe defoliation in a wet season, especially on Siberian elm. Defoliation in spring means death of twigs, but the disease is more common and less important toward fall. Ascospores are formed in spring in perithecia on fallen dead leaves; conidia are produced as a creamy exudate of spores in summer. The fungus also winters as mycelium in dormant buds.
Control. Rake and burn fallen leaves. Chemical control is required only in a wet spring, difficult to determine in advance.

Gnomoniella

Ascomycetes, Diaporthales

Perithecia in substratum, beaked, membranous, separate; spores hyaline, one-celled.

Gnomoniella coryli (see *Mamianiella coryli*). **Leaf Spot** on hazel, frequent in northern states.
Gnomoniella fimbriata (see *Mamianiella fimbriata*). **Leaf Spot** of hornbeam.
Mamianiella coryli (formerly *Gnomoniella coryli*). **Leaf Spot** on hazel, frequent in northern states. Controlled with bordeaux mixture aided by cleaning up fallen leaves.
Mamianiella fimbriata (formerly *Gnomoniella fimbriata*). **Leaf Spot** of hornbeam.

Gonatobotryum

Deuteromycetes, Hyphomycetes

Conidiophores dark, with spiny inflations at intervals, around which are borne ovoid, dark, one celled conidia.

Gonatobotryum apiculatum. **Leaf Spot** on witchhazel.

Graphium

Deuteromycetes, Hyphomycetes

Synnema or coremium tall, dark, with a rounded terminal mass of conidia embedded in mucus; simple, hyaline conidiophores; oblong conidia reproducing by budding; parasitic.

Graphium sorbi. **Leaf Spot** of mountain-ash.

Guignardia

► Blotch Diseases.

Guignardia bidwellii f. sp. **parthenocissi**. **Leaf Spot** on Boston ivy, pepper-vine, and Virginia creeper. Spots are numerous, angular, reddish brown, usually dark brown at margins, with black dots in center, minute pycnidia of the anamorph *Phyllosticta* state. Leaves are quite unsightly and there may be defoliation. Bordeaux mixture applied two or three times, starting as leaves are expanding, gives some control, but the "cure" looks about as bad as the disease. This fungus is a form of the species causing black rot of grapes.

Helminthosporium

► Blights.

Bipolaris cynodontis (formerly *Helminthosporium cynodontis*). **Bermuda Grass Leaf Blotch**, general in South. Olive brown indefinite lesions on dry leaves.

Bipolaris setariae (formerly *Helminthosporium setariae* (*Drechslera setariae*)). **Leaf and Petal or Greasy Spot** on geranium, areca palm, fishtail palm, rhapis palm, *Calathea* spp. *Maranta* spp., and *Chamaedorea* spp.

Bipolaris sorokiniana (formerly *Helminthosporium sativum*). **Melting-out**, prevalent on bent grass in warm weather. **Leaf Spot** on Russian wildrye (*Elymus*); **Spot Blotch** on switchgrass (*Panicum*).

Bipolaris sorokiniana (formerly *Helminthosporium sorokiniana*). **Leaf Spot** and **Stem Spot** of wild rice. **Leaf and Pod Spot** on bean.

Drechslera catenaria (formerly *Helminthosporium catenarium*). **Leaf Spot** on ribbon-grass.

Drechslera dictyoides (formerly *Helminthosporium dictyoides*). **Fescue Netblotch**, general on fescue. Dark streaks across green leaves with darker lengthwise streaks form a net pattern. Leaves turn yellow and die back from tips.

Drechslera erythrospilum (formerly *Helminthosporium erythrospilum*). **Red Leaf Spot** on redtop and bent grasses, widespread in eastern and midwestern states. Under wet conditions lesions have small, pale centers with russet borders; in dry weather leaves wither as in drought but with less evident spotting. Conidia are typically cylindrical, rounded at both ends, yellowish, and germinate from any or all cells (see Fig. 3.23).

Drechslera giganteum (formerly *Helminthosporium giganteum*). **Zonate Leaf Spot**, **Eye Spot** on bent grasses, Canada and Kentucky bluegrass, and Bermuda grass. The disease is present in turf and in nursery rows. Spots are small, 1/16 to 1/8 inch, bleached-straw color in centers. In presence of moisture (dew is sufficient) the fungus grows periodically into new areas, giving the zoned appearance. In continued wet weather leaves are killed and grass turns brown. Metropolitan and velvet bent grasses are less susceptible. Most injury is in July and August. The fungus overwinters as dormant mycelium in old leaves.

Drechslera poae (formerly *Helminthosporium vagans*). **Bluegrass Leaf Spot**, **Going-Out**, **Melting-out**, **Foot Rot**, general but most injurious in northeastern states, on bluegrass only. Scattered circular to enlongate leaf spots, 0.5 to 3 by 1 to 8 mm, have prominent reddish brown to black borders; centers are brown changing to straw-colored or white with age. The disease, favored by cool rainy weather, usually appears in early spring, sometimes in late fall, and is most severe on close-clippped turf. Grass thins out in large areas; roots rot; weeds invade exposed soil.

Control. Merion bluegrass is quite resistant to leaf spot and will stand close-clipping. For other bluegrasses cut high and fertilize well to help turf withstand the disease.

Drechslera siccans (formerly *Helminthosporium siccans*; Teleomorph, *Pyrenophora lolii*). **Brown Blight** on fescue, and ryegrass. Leaves die back with numerous dark chocolate-brown spots, oval to elongate and often coalescing. The disease appears in early spring in cool, moist weather.

Drechslera stenacra (formerly *Helminthosporium stenacrum*). **Leaf Mold** on redtop and bent grasses. Indefinite spots; leaves dry, withered, in fall.

Drechslera triseptata (formerly *Helminthosporium triseptatum*). **Leaf Spot**, **Gray Leaf Mold** on redtop, spike and bentgrasses in Oregon, Washington, and New York. Leaf tips are killed with vague lesions; gray mold appears on dying tissue.

Drechslera tritici-repentis (formerly *Helminthosporium tritici-repentis*). **Leaf Spot** on Russian wildrye (*Elymus*).

Exserohilum rostratum (formerly *Helminthosporium rostratum*). **Leaf Spot** on bromelia, areca palm, fishtail palm, rhapis palm, sweet sorghum, and *Chamaedorea* spp.

Helminthosporium catenarium (see *Drechslera catenaria*). **Leaf Spot** on ribbon-grass.

Helminthosporium cynodontis (see *Bipolaris cynodontis*). **Bermuda Grass Leaf Blotch**, general in South.

Helminthosporium dictyoides (see *Drechslera dictyoides*). **Fescue Net-blotch**, general on fescue.

Helminthosporium erythrospilum (see *Drechslera erythrospilum*). **Red Leaf Spot** on redtop and bent grasses, widespread in eastern and midwestern states.

Helminthosporium giganteum (see *Drechslera giganteum*). **Zonate Leaf Spot**, **Eye Spot** on bent grasses, Canada and Kentucky bluegrass, and Bermuda grass.

Helminthosporium rostratum (see *Exserohilum rostratum*). **Leaf Spot** on bromelia, areca palm, fishtail palm, rhapis palm, sweet sorghum, and *Chamaedorea* spp.

Helminthosporium sativum (see *Bipolaris sorokiniana*). **Melting-out**, prevalent on bent grass in warm weather. **Leaf Spot** on Russian wildrye (*Elymus*); **Spot Blotch** on switchgrass (*Panicum*).

Helminthosporium setariae (*Drechslera setariae*) (see *Bipolaris setariae*). **Leaf and Petal or Greasy Spot** on geranium, areca palm, fishtail palm, rhapis palm, *Calathea* spp. *Maranta* spp., and *Chamaedorea* spp.

Helminthosporium siccans; Teleomorph, *Pyrenophora lolii* (see *Drechslera siccans*). **Brown Blight** on fescue, and ryegrass.

Helminthosporium sorokiniana (see *Bipolaris sorokiniana*). **Leaf Spot** and **Stem Spot** of wild rice. **Leaf and Pod Spot** on bean.

Helminthosporium stenacrum (see *Drechslera stenacra*). **Leaf Mold** on redtop and bent grasses.

Helminthosporium triseptatum (see *Drechslera triseptata*). **Leaf Spot**, **Gray Leaf Mold** on redtop, spike and bentgrasses in Oregon, Washington, and New York.

Helminthosporium tritici-repentis (see *Drechslera tritici-repentis*). **Leaf Spot** on Russian wildrye (*Elymus*).

Helminthosporium vagans (see *Drechslera poae*). **Bluegrass Leaf Spot**, **Going-Out**, **Melting-out**, **Foot Rot**, general but most injurious in northeastern states, on bluegrass only.

Hendersonia

Deuteromycetes, Coelomycetes

Pycnidia smooth, innate or finally erumpent, ostiolate; conidia dark, several-celled, elongate to fusoid; saprophytic or parasitic.

Hendersonia concentrica. **Leaf Spot** on rhododendron.
Hendersonia crataegicola. **Leaf Spot** on hawthorn. Spots irregular, dark brown.

Cladosporium (Heterosporium)

Deuteromycetes, Hyphomycetes

Conidiophores dark, simple; conidia dark, spiny, cylindrical, with three or more cells; parasitic, causing leaf spots, or saprophytic.

Acroconidiella escholtziae (formerly *Heterosporium escholtziae*). **Capsule Spot**, **Leaf Spot**, **Stem Spot** of California poppy. Lesions faint purplish brown; seed capsules may shrivel. Treat seed with hot water, 125°F, for 30 minutes.
Cladosporium allii (formerly *Heterosporium allii*). **Leaf Spot** on onion, leek, shallot, chive, and garlic; rare in North America. Leaves have elliptical, depressed, pale brown spots, and yellow and wither from tip downward.
Cladosporium echinulatum (formerly *Heterosporium echinulatum*). **Fairy Ring Spot**, **Leaf Mold** on carnation, occasional in greenhouses. Bleached spots on leaves have black spore groups in ring formation. Syringe as little as possible and on bright days; control ventilation.
Cladosporium iridis (formerly *Heterosporium gracile*). **Leaf Spot** on chlorogalum, daylily, same as *H. iridis* on iris (conidial state of *Didymellina macrospora*). **Leaf Spot** on iris, blackberry, lily, freezia, and gladiolus.
Cladosporium variabile (formerly *Heterosporium variabile*). **Leaf Spot**, pinhead “rust” of spinach, cabbage mold, sometimes severe in cold, wet weather. Circular, chlorotic spots with brown or purple margins enlarge and multiply until they cover most of the leaf, which turns yellow, withers, dies. There is a greenish black mold on both leaf surfaces, made up of large olive conidia, one- to six-celled, covered with warts. Keep plants growing vigorously in wall-drained soil.

Heterosporium allii (see *Cladosporium allii*). **Leaf Spot** on onion, leek, shallot, chive, and garlic; rare in North America.
Heterosporium echinulatum (see *Cladosporium echinulatum*). **Fairy Ring Spot**, **Leaf Mold** on carnation, occasional in greenhouses.
Heterosporium escholtziae (see *Acroconidiella escholtziae*). **Capsule Spot**, **Leaf Spot**, **Stem Spot** of California poppy.
Heterosporium gracile (see *Cladosporium iridis*). **Leaf Spot** on chlorogalum, daylily, same as *H. iridis* on iris (conidial state of *Didymellina macrospora* (Fig. 3.25)). **Leaf Spot** on iris, blackberry, lily, freezia, and gladiolus.
Heterosporium variabile (see *Cladosporium variabile*). **Leaf Spot**, pinhead "rust" of spinach, cabbage mold, sometimes severe in cold, wet weather.

Illosporium

Deuteromycetes, Hyphomycetes

Sporodochia cushionlike, light-colored; conidiophores hyaline, branched with phialides bearing conidia apically; spores hyaline, one-celled; parasitic or saprophytic, often secondary.

Illosporium malifoliorum. **Leaf Spot** of apple and crabapple.

Isariopsis

Deuteromycetes, Hyphomycetes

Dark, synnemata composed of loose conidiophores with spores at or near tips; conidia dark or pale, with two or more cells, cylindrical to obclavate, often curved; parasitic.

Isariopsis griseola (see *Phaeoisariopsis griseda*). **Angular Leaf Spot**, **Pod Spot** of beans, also sweet pea.
Phaeoisariopsis griseda (formerly *Isariopsis griseola*). **Angular Leaf Spot**, **Pod Spot** of beans, also sweet pea. Small, angular brown spots are so numerous they give a checkerboard appearance to leaves. The fungus forms a gray moldy covering over dead areas on underside of leaves. Pod spots are conspicuous when present, black with red or brown centers, varying from a speck to the width of the pod. Small, dark synnemata scattered over

the surface bear large conidia, with two to four cells, at top of stalks. They are probably wind-disseminated. Control measures are seldom practical. Also, **Leaf Spot** on kidney bean.

Kabatia

Deuteromycetes, Coelomycetes

Pycnidia with a radiate shield or scutellum, with an ostiole; spores two-celled, hyaline, like a tooth at the apex.

Kabatia lonicerae. **Leaf Spot** on honeysuckle.

Lasiobotrys

Ascomycetes, Dothideales

Perithecia in a ring around a sclerotial stroma; spores dark, two-celled.

Lasiobotrys lonicerae. **Leaf Spot** on honeysuckle. Spot is well-marked with small, dark, wartlike stromas.

Leptostromella

Deuteromycetes, Coelomycetes

Pycnidia elongate, with a cleft; separate; spores filiform, with rounded ends, hyaline, continuous to septate on simple conidiophores.

Leptostromella elastica. **Leaf Spot** of rubber-plant. The symptoms appear in spots and streaks, but infection spreads until the entire leaf is involved. Black lines outline spots in which small black pycnidia produce long, colorless spores. Remove and burn infected leaves.

Leptothyrella

Deuteromycetes, Coelomycetes

Pycnidia with a radiate shield, separate; spores 2-celled, hyaline.

Leptothyrella liquidambaris (see *Tubakia dryina*). **Leaf Spot** red on sweetgum.
Tubakia dryina (formerly *Leptothyrella liquidambaris*). **Leaf Spot** red on sweetgum.

Leptothyrium

Deuteromycetes, Coelomycetes

Pycnidium flattened with a more or less radiate shield, opening with a ostiole; spores one-celled, hyaline, on simple conidiophores.

Kabatia periclymeni (formerly *Leptothyrium periclymeni*). **Leaf Spot** on honeysuckle, widespread.
Leptothyrium californicum. **Leaf Spot** on coast live oak.
Leptothyrium dryinum (see *Tubakia dryina*). **Leaf Spot** on white oak.
Leptothyrium periclymeni (see *Kabatia periclymeni*). **Leaf Spot** on honeysuckle, widespread.
Tubakia dryina (formerly *Leptothyrium dryinum*). **Leaf Spot** on white oak.

Linospora

Ascomycetes, Diaporthales

Perithecia innate, beak often lateral, with a shield; paraphyses lacking; spores spindle-shaped to filiform, hyaline.

Linospora gleditschiae. **Leaf Spot**, **Tar Spot** on honey locust in the South. Numerous black fruiting bodies are formed on undersurface of leaves.

Lophodermium

Ascomycetes, Rhytismatales

Fruiting body a hysterothecium, midway between an elongated perithecium and a compressed apothecium, hard, black, opening with a long narrow slit; paraphyses present; hooked at tip; spores filiform, septate or continuous. Most species cause needle casts.

Lophodermium schweinitzii. **Rhododendron Leaf Spot**. Large silvery white spots with red, raised margins have very prominent oval, black fruiting bodies on the upper surface. Lower side of spots is a light chocolate brown.

Infected portions may fall out, leaving irregular holes. The disease is more common on native than on hybrid varieties.

Macrophoma

► Cankers.

Macrophoma candollei. **Leaf Spot** of boxwood. Conspicuous black pycnidia on dead leaves, usually straw-colored, sometimes brown or tan. The fungus is a weak parasite coming in secondarily after winter injury or other predisposing factors.

Marssonina

► Anthracnose.

Cylindrosporium populinum (formerly *Marssonina rhabdospora*; Teleomorph, *Pleuroceras populi*). **Leaf Spot** of poplar. Brown spots on living leaves; beaked pyriform perithecia formed in fallen leaves over winter.

Didymosporina aceris (formerly *Marssonina truncatula*). **Leaf Spot** and **Leaf Blight** of Norway maple.

Diplosporonema delastrei (formerly *Marssonina delastrei*). **Leaf Spot** on corncockle and campion.

Discella ochroleuca (formerly *Marssonina ochroleuca*). **Leaf Spot** on oak, American chestnut. Spots are circular, yellow to brown with concentric markings, small on chestnut, up to an inch on oak.

Marssonina daphnes. **Daphne Leaf Spot**. Small, thick brown spots on both sides of leaf, which turns yellow, dies.

Marssonina delastrei (see *Diplosporonema delastrei*). **Leaf Spot** on corncockle and campion.

Marssonina fraxini (see *Piggotia fraxini*). **Ash Leaf Spot**, sometimes serious in nursery stock, controlled by spraying with bordeaux mixture.

Marssonina juglandis. See *Gnomonia leptostyla* under Anthracnose.

Marssonina ochroleuca (see *Discella ochroleuca*). **Leaf Spot** on oak, American chestnut.

Marssonina populi. **Poplar Leaf Spot**. Brown spots with darker margins. There may be premature defoliation and killing of twigs.

Marssonina rhabdospora (Teleomorph, *Pleuroceras populi*) (see *Cylindrosporium populinum*). **Leaf Spot** of poplar.
Marssonina rosae. Anamorph state of the rose blackspot fungus, *Diplocarpon rosae*.
Marssonina tremulae. **Leaf Spot** on poplar.
Marssonina truncatula (see *Didymosporina aceris*). **Leaf Spot** and **Leaf Blight** of Norway maple.
Piggotia fraxini (formerly *Marssonina fraxini*). **Ash Leaf Spot**, sometimes serious in nursery stock, controlled by spraying with bordeaux mixture.

Mastigosporium

Deuteromycetes, Hyphomycetes

Conidiophores hyaline, very short, simple; conidia with four or more cells, with or without apical appendages: broadly cylindrical with rounded or pointed ends; parasitic on grasses.

Mastigosporium rubricosum. **Leaf Fleck** on redtop and bent grasses. Spores with rounded ends, without appendages.

Melanconium

Deuteromycetes, Coelomycetes

Acervuli subcutaneous or subcortical, conic or discoid, black; with setae; conidiophores simple; conidia dark, one-celled, ovoid to ellipsoid; parasitic or saprophytic.

Melanconium pandani. **Leaf Spot** on pandanus.

Melasmia

Deuteromycetes, Coelomycetes

Pycnidia in a broad, black, flattened stroma that is superficial or nearly so, dimidiate; conidiophores simple or branched; spores hyaline or subhyaline, one-celled, allantoid or fusoid; parasitic on leaves; anamorph states of *Rhytisma*.

Melasmia falcata. **Tar Spot** of persimmon.
Melasmia menziesiae. **Leaf Spot** tar spot of azalea.

Micropeltis

► Blights.

Micropeltis alabamensis. **Black Leaf Spot** on magnolia.

Microstroma

Basidiomycetes, Exobasidiales

Sporodochia small, white, breaking through epidermis; conidiophores hyaline, one-celled, somewhat clavate, bearing conidia on short sterigmata; spores hyaline, one-celled, small, oblong; parasitic. "Conidia" are now known to be basidiospores.

Microstroma juglandis. **Leaf Spot**, **White Mold**, **Downy Spot**, **Witches' Broom** of pecan, walnut, and hickory. Yellow blotching of upper side of leaves and a glistening white coating on underside, due to pustules with enormous numbers of spores, may be accompanied by premature defoliation. On shagbark hickory the fungus also invades the stems, causing witches' brooms up to 3 feet across. Leaves formed on them in spring are yellow-green, with white powder on underside. Leaflets are small, curled, and soon drop. Prune out witches' brooms; spray with bordeaux mixture.

Microthyriella

► Fruit Spots.

Microthyriella cuticulosa. **Black Spot** of holly. Dark spots on leaves of American holly, Georgia.

Monochaetia

► Cankers.

Monochaetia monochaeta. **Leaf Spot** on chestnut, white, red, and coast live oaks, winged elm, hickories, especially destructive in the Southeast. Spots are large, 1 to 2 inches in diameter, with pale green or yellow centers with a red and brown border or concentric zones of gray, yellow, and brown.

Symptoms appear most often in late summer when loss of green tissue is not so important.

Lembosina (Morenoella)

See *Lembosia* under Black Mildew.

Lembosina quercina (formerly *Morenoella quercina*). **Leaf Spot**, **Black Mildew** of red and black oaks; twig blight of white oak, common in Southeast. Spots are purplish black, roughly circular, up to 1/3 inch across, on upper surface and irregular brown areas on underside. Mycelium is superficial in early summer, but by late summer there are subcuticular hyphae and a black shield formed over a flat cushion of fertile cells. Asci are mature and shield is fissured by spring.

Morenoella quercina (see *Lembosina quercina*). **Leaf Spot**, **Black Mildew** of red and black oaks; twig blight of white oak, common in Southeast.

Mycosphaerella

► Blights.

Mycosphaerella angulata. **Angular Leaf Spot** of muscadine grapes. Many small, angular black spots, more conspicuous on lower surface of leaves, which may turn yellow and die.

Mycosphaerella arachidis. **Peanut Leaf Spot**. ► *Cercospora arachidicola*.

Mycosphaerella berkeleyi. **Peanut Leaf Spot**. ► *Cercospora personata*.

Mycosphaerella (Anamorph, Pseudcercospora) **bolleana**. **Leaf Spot** of fig, and rubber-tree.

Mycosphaerella (Anamorph, Asteromella brassicae) **brassicicola**. **Ring Spot** of crucifers, chiefly cabbage and cauliflower, sometimes brussels sprouts, broccoli, and turnip. Dead spots in leaves, small to 1/2 inch, are surrounded by a green zone that keeps its color even if the rest of the leaf turns yellow. Small black pycnidia are deeply embedded in the dead tissue, often in concentric rings. In moist weather conidia ooze from pycnidia in pink tendrils. The fungus winters in old plant refuse, and ascospores are forcibly ejected from perithecia in spring. The disease is confined to the Pacific Coast and, as black blight, is serious on the seed crop in the Puget Sound area. Sanitary measures and crop rotation keep it in check.

Mycosphaerella caroliniana. **Leaf Spot**, **Purple Blotch** on oxydendron (sourwood). Reddish or purple spots on foliage in midsummer have dry, brown centers. Pycnidia embedded in tissue break through lower surface, spores being formed in great numbers.

Mycosphaerella caryigena. **Pecan Downy Spot**. Conidial stage has been listed as a *Pseudocercosporella caryigena*. Leaf spots are pale yellow when young, turning yellow-brown, brown, or black. Conidia produced in minute acervuli on underside of leaves form a white downy or frosty coating; leaves may drop early. Spores are spread in rain, fog, and dew. The fungus overwinters in leaves, liberating ascospores in spring to infect new foliage. Moneymaker and Stuart varieties are especially susceptible.

Control. Turn under old leaves before spring (plowing under winter cover in spring takes care of this). Spray as for scab, bordeaux mixture when leaves are half-grown and bordeaux plus 4 pounds of zinc sulfate when tips of small nuts have turned brown.

Mycosphaerella cerasella. ► *Cercospora circumscissa.*

Mycosphaerella (Anamorph, *Cercospora*) **cercidicola**. **Redbud Leaf Spot**, general. Spots are circular to angular or irregular with raised dark brown borders. With age, lesions become grayish above and rusty brown on the undersurface, with the leaf tissue yellow-green outside the borders. Spores are formed on fascicles of conidiophores projecting through stomata. The fungus winters on fallen leaves, producing perithecia in spring. Twigs may be attacked as well as foliage.

Mycosphaerella citri. **Leaf Spot or Greasy Spot** on citrus.

Mycosphaerella colorata. **Mountain-Laurel Leaf Spot**. ► *Phyllosticta kalmicola*.

Mycosphaerella (Anamorph, *Pseudocercospora cruenta*) **cruenta**. **Leaf Spot**, **Leaf Blotch** of soybean, and kidney bean. Leaf spots distinct to indistinct, circular to irregular, greenish to yellowish to rusty brown to almost red, sometimes with gray centers.

Mycosphaerella effigurata (Anamorph, *Piggotia fraxini*). **Ash Leaf Spot**, general east of the Plains. Spots small, purple to brown with yellow borders.

Mycosphaerella fragariae. **Strawberry Leaf Spot**, **Black-Seed Disease**, general on strawberries. Leaf spots are first purple then reddish with light brown or white centers, 1/8 to 1/4 inch across. Spots are also present on petioles and fruit stems, and occasionally there are black spots on fruit, with blackened achenes prominent against the white of unripe berries. Fruit is poor; total yield is reduced; runner plants are weakened. Conidia of the *Ramularia* stage are produced in clusters of short conidiophores on underside of diseased areas; perithecia are formed in autumn at the edge of the leaf spots where the fungus winters. New conidia are produced in spring with most infection taking place through stomata. There is a difference in varietal susceptibility.

Control. Set healthy plants in well-drained soil; remove diseased leaves before planting; spray with bordeaux mixture before planting and follow with two or three more applications. The conidia are very sensitive to copper, which prevents sporulation and kills nongerminated spores.

Mycosphaerella fraxinicola (Anamorph, *Phyllosticta viridis*). **Ash Leaf Spot**, east of the Rocky Mountains.

Mycosphaerella juglandis. **Leaf Spot** of black walnut.

Mycosphaerella liriodendri (*Phyllosticta liriodendrica*). **Tulip-Tree Leaf Spot**.

Mycosphaerella louisianae. **Purple Leaf Spot** of strawberry, in the South. Large, irregular, reddish purple areas.

Mycosphaerella mori. **Mulberry Leaf Spot**, widespread, with the conidial stage reported variously as *Cercosporella, Cylindrosporium, Phloeospora, Septogloeum*, and *Septoria*. Yellow areas on upper leaf surface are matched by whitish patches underneath, the fungus forming a white downy or powdery coating. The disease is most serious in shady locations.

Mycosphaerella nigromaculans. **Black Stem Spot** of cranberry, reported from all cranberry areas, often associated with red leaf spot. The fungus enters through leaves, grows down the petioles, and forms elongated black spots on the stems, which may be completely girdled, followed by defoliation. Fruiting bodies are produced in autumn on dead stems with ascospores discharged in rainy periods in spring. The anamorph state of the fungus is a *Ramularia nigromaculans*.

Mycosphaerella nyssicola (Anamorph, *Phyllosticta nyssae*). **Tupelo Leaf Spot**, on sour gum and water tupelo. Purplish irregular blotches, an inch or more across, are scattered on upper leaf surface with lower surface dark brown. There may be heavy defoliation. Perithecia mature in spring on fallen leaves.

Mycosphaerella personata (Anamorph, *Isariopsis clavispora*). **Leaf Spot**, widespread on muscadine and other grapes after midseason. Spots are dark brown, 1/4 to 1/2 inch, surrounded by a yellow circle but with a narrow band of normal green between spot and circle.

Mycosphaerella populicola (Anamorph, *Septoria populicola*); **M. populorum** (*S. musiva*). **Leaf Spot** of native poplar; **Canker** on twigs and branches of hybrid poplars.

Mycosphaerella psilospora (Anamorph, *Septoria querceti*). **Oak Leaf Spot** on red and other oaks, common in Iowa. Spots very small, circular, with strawcolor centers and dark margins.

Mycosphaerella ribis. **Leaf Spot** of flowering currant.

Mycosphaerella ribis (*M. grossulariae*, Anamorph, *Septoria ribis*). **Leaf Spot** of gooseberry, current. Numerous small brown spots with grayish centers are formed on both sides of leaves; there may be premature defoliation. The fungus winters in leaves, producing ascospores in late spring. Two sprays of bordeaux mixture plus 1 pint of self-emulsifying cottonseed oil per 100 gallons have given good control of leaf spot on gooseberries in New York. The first application is about June 1, the second in July right after fruit is picked.

Mycosphaerella rosicola. ► *Cercospora rosicola.*

Mycosphaerella rubi. ► *Septoria rubi.*

Mycosphaerella pyri (Anamorph, *Septoria pyricola*). **Pear Leaf Spot**, also on quince, occasional on apple. Spots are small, 1/8 to 1/4 inch, grayish in center, dotted with black fruiting bodies, with a well-defined dark brown margin. There are marked differences in susceptibility in pear varieties. Flemish Beauty, Duchess, and Winter Nellis are moderately, and Kieffer very, resistant. Sprays applied for leaf blight or scab control leaf spot.

Mycocentrospora

Mycocentrospora verrucosa. **Leaf Spot** on euonymus.

Myrothecium

Deuteromycetes, Hyphomycetes

Sporodochia cushionlike, light or dark; conidiophores subhyaline to colored, repeatedly branched, bearing conidia terminally; conidia subhyaline to dark, one-celled, ovoid to elongate; weakly parasitic or saprophytic.

Myrothecium roridum. **Leaf Spot** on snapdragon, stock, eremurus, gardenia, hollyhock, aeschynanthus, aglaonema, aphelandra, dieffenbachia, episcia, fittonia, nematanthus, hoya, peperomia, pilea, and sphathiphyllum. Tissues are dry, brittle, with black sporodochia. Snapdragon leaves and flowering stems wilt, with sunken cracked cankers. Avoid excessive moisture; sterilize soil.

Nematostoma

Ascomycetes, Dothideales

Nematostoma occidentalis. **Leaf Hair Discoloration** on Artemisa.

Neottiospora

Deuteromycetes; Coelomycetes

Pycnidia dark, smooth, innate; spores hyaline, one-celled with two to several appendages at the apex.

Alpakesa yuccifolia (formerly *Neottiospora yuccifolia*). **Yucca Leaf Spot**.
Neottiospora yuccifolia (see *Alpakesa yuccifolia*). **Yucca Leaf Spot**.

Ophiodothella

Ascomycetes, Phyllachorales

Asci in locules immersed in groups in a stroma, covered by host tissue at maturity; paraphyses lacking; spores filiform.

Ophiodothella vaccinii. **Leaf Spot** on huckleberry, and farkleberry.

Ovularia

Deuteromycetes, Hyphomycetes

Conidiophores emerging from leaves in clusters, simple or branched; conidia hyaline, one-celled, ovoid or globose, apical or lateral, single or sometimes catenulate; parasitic.

Ovularia aristolochiae. **Leaf Spot** on Dutchmans-pipe.
Ovularia pulchella (see *Ramularia pusilla*). **Tan Leaf Spot** on creeping bent grass.

Ramularia pusilla (formerly *Ovularia pulchella*). **Tan Leaf Spot** on creeping bent grass.

Pestalotia

► Blights.

Pestalotia aquatica (see *Pestalotiopsis aquatica*). **Leaf Spot** of arrow-arum.
Pestalotia aucubae. **Aucuba Leaf Spot**. The fungus appears as a weak parasite in sunscald spots or after other fungi.
Pestalotia cliftoniae. **Leaf Spot** on buckwheat-tree. Ashy or pale brown spots. Spores usually curved, constricted at septa, three setae at crest.
Pestalotia funerea (see *Pestalotiopsis funerea*). **Leaf Spot**, **Bark and Cone Spot** on conifers.
Pestalotia guepini (see *Pestalotiopsis maculans*). **Camellia Leaf Spot**, widespread.
Pestalotia leucothoës (see *Pestalotiopsis leucothoës*). **Leucothoë Leaf Spot**, apparently following winter injury or other disease.
Pestalotia macrotricha (see *Pestalotiopsis quepini* var. *macrotricha*). **Rhododendron Leaf Spot**, gray blight, twig blight, widespread on azalea and rhododendron after winter injury.
Pestalotia palmarum (see *Pestalotiopsis palmarum*). **Palm Leaf Spot**, **Gray Leaf**. **Pestalotia rhododendri** (see *Pestalotiopsis sydowiana*). **Rhododendron Leaf Spot**.
Pestalotiopsis aquatica (formerly *Pestalotia aquatica*). **Leaf Spot** of arrow-arum. Irregular, chestnut-brown spots, up to an inch in diameter, have purplish or dark borders and are wrinkled concentrically. Acervuli are sparse, black, erumpent on upper side of leaf. Spores are five-celled with three widely divergent setae.
Pestalotiopsis funerea (formerly *Pestalotia funerea*). **Leaf Spot**, **Bark and Cone Spot** on conifers. Pathogenicity of the fungus is questionable. Median spore cells are dark brown; apical hyaline cell has four or five erect setae.
Pestalotiopsis leucothoës (formerly *Pestalotia leucothoës*). **Leucothoë Leaf Spot**, apparently following winter injury or other disease.
Pestalotiopsis maculans (formerly *Pestalotia guepini*). **Camellia Leaf Spot**, widespread. Numerous, punctiform black fruiting bodies are scat-

tered over papery gray spots. The spores are five-celled, bright olivaceous, with one to four divergent, sometimes branched, setae, and a straight, short pedicel. This species seems to be a true parasite.

Pestalotiopsis palmarum (formerly *Pestalotia palmarum*). **Palm Leaf Spot**, **Gray Leaf**. Black pustules are sparsely produced on both surfaces of pale, dead areas with definite, reddish brown borders. Spores are five-celled, with two or three setae, usually knobbed. The fungus is a wound parasite.

Pestalotiopsis quepini var. **macrotricha** (formerly *Pestalotia macrotricha*). **Rhododendron Leaf Spot**, gray blight, twig blight, widespread on azalea and rhododendron after winter injury. Dark or pale spots with black raised pustules are scattered over stems and leaves. Spots are often silvery gray on upper surface and dark brown underneath, with densely gregarious acervuli sooty from dark spores.

Pestalotiopsis sydowiana (formerly *Pestalotia rhododendri*). **Rhododendron Leaf Spot**. Black pustules are scattered without order over dried brown areas of living leaves. Spores are broader than those of *P. macrotricha* and have shorter setae.

Pestalozziella

Deuteromycetes, Coelomycetes

Conidia hyaline, one-celled, with a branched appendage at apex; acervuli subcutaneous; conidophores slender, simple or branched.

Pestalozziella subsessilis. **Leaf Spot** on geranium.

Pezizella (Allophylaria)

Ascomycetes, Helotiales

Apothecia sessile, bright-colored, smooth; paraphyses filiform, blunt; spores elliptical to fusoid, hyaline, one-celled.

Discohainesia oenotherae (formerly *Pezizella* (*Discohainesia*) *oenotherae*). **Leaf Spot**, **Fruit Rot** of blackberry, raspberry, and strawberry; leaf spot of evening primrose, eugenia, galax, loosestrife, ludwigia, mock-strawberry, May-apple, peony, and sumac. Spots are irregular, gray in center with a dark brown border. Fruiting bodies are light amber discs; spores are amber in masse.

Pezizella (Discohainesia) oenotherae (see *Discohainesia oenotherae*). **Leaf Spot**, **Fruit Rot** of blackberry, raspberry, and strawberry; leaf spot of evening primrose, eugenia, galax, loosestrife, ludwigia, mock-strawberry, May-apple, peony, and sumac.

Phacidium

► Blights.

Phacidium curtisii. **Tar Spot**, **Leaf Spot** of American holly, more serious in southern commercial plantings. Small yellow spots appearing in early summer age to reddish brown with narrow yellow borders. At end of season flat, black, cushion-shaped stromata develop beneath the epidermis. Leaves seldom drop prematurely, but infected areas may fall out leaving holes. In years of heavy rainfall berries as well as leaves are spotted. Remove lower branches; clean up and burn or turn under fallen leaves. Spray with bordeaux mixture.

Phaeosphaeria

Ascomycetes; Dothideales

Phaeosphaeria maydis. **Leaf Spot** on sweet corn.

Phaeotrichoconis

Deuteromycetes, Hyphomycetes

Phaeotrichoconis crotalariae. **Leaf Spot** on areca palm; leaf spots on palms which are similar in appearance are caused more often by *Bipolaris, Helminthosporium setariae* and *Helminthosporium (Exserohilum) rostratum*.

Phloeospora

► Blights.

Phloeospora aceris. **Leaf Spot** of maple, including vine and dwarf maples. The spot is small, rather angular, common but not important.

Phoma

▶ Blackleg.

Phoma sp. **Leaf Spot** on ragweed.

Phomopsis

▶ Blights.

Phomopsis viticola. **Leaf Spot** on grape.

Phlyctema

Deuteromycetes, Coelomycetes

Pycnidia dark, separate or sometimes confluent, in or under epidermis or bark; closed or ostiolate; conidiophores simple or forked; conidia hyaline, one-celled, cylindrical or long spindle-shaped, mostly bent, sickle-shaped; saprophytic usually.

Phlyctema ficuum. **Leaf Spot** on strangler fig.

Phyllachora

Ascomycetes, Phyllachorales

Asci in locules, immersed in groups in a dark stroma covered by host tissue at maturity; spores one-celled, hyaline; paraphyses present; asci cylindrical with short pedicels.

Phyllachora graminis. **Tar Spot**, **Black Leaf Spot**, general on wheatgrass, ryegrass, fescues, redtop, and bent grass. Elongated grayish violet to dark olive green spots, on both leaf surfaces, turn glossy black. The disease is seldom serious.

Phyllachora sylvatica. **Tar Spot** on fescues in Northwest.

Phyllosticta

► Blights.

Asterostomella saccardoi (formerly *Phyllosticta saccardoi*). **Rhododendron Leaf Spot**, similar to that caused by *P. maxima*.

Discochora philoprina (formerly *Phyllosticta ilicis* (Teleomorph, *Physalospora ilicis*)). **Holly Leaf Spot** on American and English holly and on winterberry.

Phoma exigua (formerly *Phyllosticta althaeina*). **Leaf Spot**, **Stem Canker** on abutilon and hollyhock. Ashy spots have black dots of pycnidia. The tissue sometimes becomes brittle and falls away, leaving jagged holes.

Phoma exigua (formerly *Phyllosticta decidua*). **Leaf Spot** of agrimony, aralia, basil weed, betony, cynoglossum, eupatorium, germander, hierachia, hoarhound, motherwort, lycopus, mint, and monarda.

Phyllosticta althaeina (see *Phoma exigua*). **Leaf Spot**, **Stem Canker** on abutilon and hollyhock.

Phyllosticta andropogonivora. **Leaf Spot** on bluestem (Andropogon).

Phyllosticta antirrhini. **Snapdragon Leaf Spot**, **Stem Rot**, **Blight**. Large circular, dark brown or black spots, with concentric ridges, are located most often near tips and margins of leaves; centers may be cream to pale brown, dotted with dark pycnidia. Young leaves may be curled, older leaves shrivel and hang down along the stem. Petioles are girdled with brown elongated lesions. Stems have firm brown rot with shoots or branches wilting or have ashy white spots with dark brown or purplish margins and stems cracking in area of spots. Young seedlings may damp off. Spray with bordeaux mixture; keep greenhouse cool; avoid wetting foliage in watering; clean up diseased plants.

Phyllosticta aucubae. **Aucuba Leaf Spot**. Brown or black zonate spots are mostly along margins of leaves, sometimes with much defoliation. Spores are exuded from leaves in yellow tendrils, then spread by rain, or syringing in the greenhouse.

Phyllosticta camelliae (syn. **P. camelliaecola**). **Camellia Leaf Spot**. Lesions are irregular brown spots.

Phyllosticta catalpae. **Catalpa Leaf Spot**. Dark brown or black spots 1/8 to 1/4 inch in diameter, may run together to give a blotched appearance. Minute black fruiting bodies pepper the spots, which are often associated with injury by the catalpa midge. Heavy infection may mean defoliation.

Phyllosticta circumscissa. **Leaf Spot**, widespread on apricot, peach, sour cherry, chokecherry, and garden plum.

Phyllosticta concentrica. **English Ivy Leaf Spot**, also a twig blight, widespread. Plants look ragged. Fruiting bodies are arranged in spots in concentric circles.

Phyllosticta cookei. **Magnolia Leaf Spot**. Spots are grayish without definite margins.

Phyllosticta decidua (see *Phoma exigua*). **Leaf Spot** of agrimony, aralia, basil weed, betony, cynoglossum, eupatorium, germander, hierachia, hoarhound, motherwort, lycopus, mint, and monarda.

Phyllosticta ilicis (Teleomorph, **Physalospora ilicis**) (see *Discochora philoprina*). **Holly Leaf Spot** on American and English holly and on winterberry.

Phyllosticta hamamelidis. **Witch-Hazel Leaf Spot**. Small spots enlarge to reddish brown blotches, causing some defoliation.

Phyllosticta hydrangeae. **Hydrangea Leaf Spot**, widespread. Brown spots usually near leaf margins; in severe cases both leaves and blossoms are killed. Spray with bordeaux mixture.

Phyllosticta kalmicola (Teleomorph, *Mycosphaerella colorata*). **Mountain-Laurel Leaf Spot**, **Kalmia Leaf Spot**. Circular, grayish white to silvery spots with red or purple borders, up to 1/4 inch across, are sparsely or thickly covered with black pycnidia (see Fig. 3.26). Heavy infection means disfigured foliage and some defoliation. The disease is worse in shady locations where shrubs are under drip of trees.

Phyllosticta maculicola. **Dracaena Leaf Spot**. Irregular small brown spots have yellowish margins and long coils of spores from black pycnidia.

Phyllosticta maxima. **Rhododendron Leaf Spot**, widespread. Spots are marginal or terminal, large, dark brown, and zonate.

Phyllosticta minima. **Maple Leaf Spot**, **Gray Spot**, also on boxelder, widespread. Spots are irregular, 1/4 inch or more across, with brownish centers, containing black pycnidia, and purple-brown margins. The disease is seldom serious enough for control measures.

Phyllosticta penicillariae. Leaf spot; also stunt chlorosis; on Pennisetum.

Phyllosticta richardiae. **Calla Leaf Spot**. Small, round, ash-gray spots run together, producing irregular decayed areas.

Phyllosticta saccardoi (see *Asterostomella saccardoi*). **Rhododendron Leaf Spot**, similar to that caused by *P. maxima*.

Phyllosticta sanguinariae. **Bloodroot Leaf Spot**. Spots reddish brown with a darker border, then a zone of Indian red.

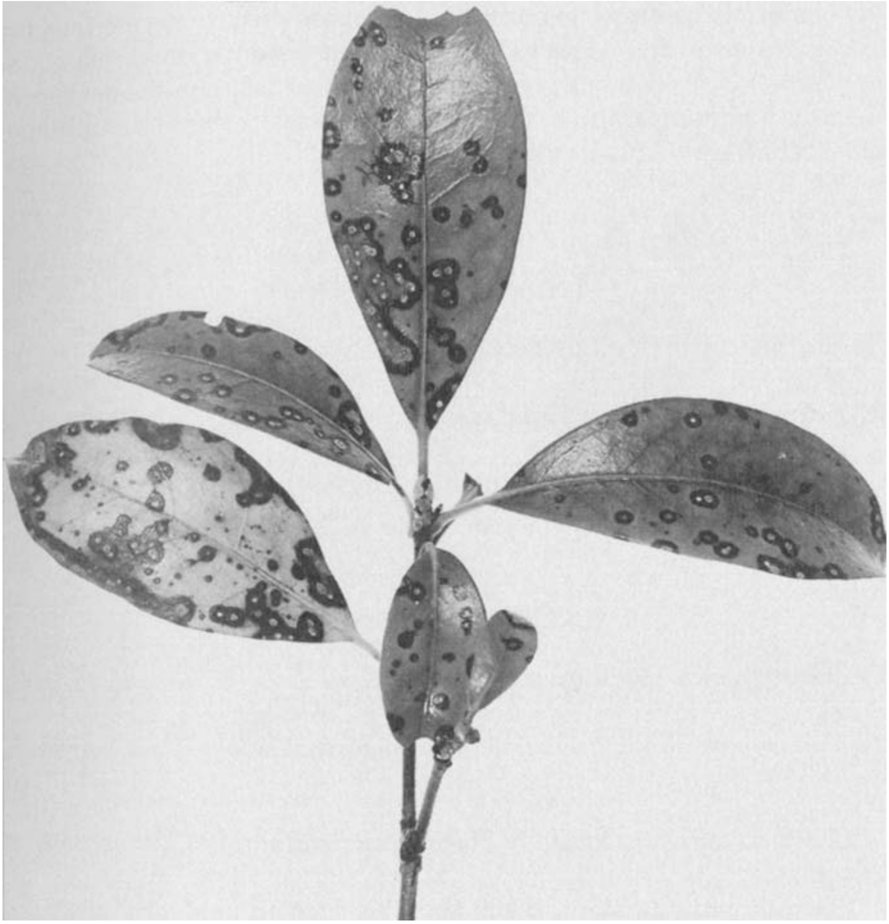


Figure 3.26 Phyllosticta Leaf Spot on Mountain-Laurel

Phyllosticta sojicola. **Leaf Spot** and **Pod Spot** of soybean; lesions have purplish red borders surrounding lighter brownish centers which contain numerous dark pycnidia (Fig. 3.26).

Phyllosticta vaccinii. **Leaf Spot** of farkleberry and highbush blueberry. Also Blueberry; Fruit Rot. Early rot, scald, blast; on cranberry. Small, circular gray spots, with one to six pycnidia in center, have brown margins. The disease is unimportant as a leaf spot; fruits have a hard, dry rot.

Phyllosticta wistariae. **Wisteria Leaf Spot**, more important in the South.

Physoderma

Chytridiomycetes, Blastocladiales

Definite mycelium with terminal and intercalary enlargements which are transformed wholly or in part into sporangia and resting spores; sporangia rare, oospores abundant, globose or ellipsoidal. Affected plant parts are discolored or slightly thickened.

Physoderma maydis. **Brown Spot** of corn, **Corn Measles**, **Corn Pox**, **Dropsy**, most prevalent in the South. Very small, bleached or yellowish spots darken to brown or reddish brown with a light margin. Adjacent spots may coalesce to give the whole blade a rusty appearance. Spots on midrib and leaf sheath are larger, up to 1/4 inch, irregular to square, darker than leaf lesions. The entire sheath may turn brown on death of host cells; the epidermis ruptures, exposing brown spore dust. In severe infections low nodes are girdled so stalks break over. The resting spores remain in soil or plant refuse over winter, germinating by swarm spores the next spring. A fairly high temperature and low, wet land favor the disease. Remove plant refuse early; rotate crops.

Phytophthora

Phytophthora ramorum. **Leaf Spot** (sudden oak death), California buckeye.

Tubackia (Pirostoma)

Deuteromycetes, Coelomycetes

Pycnidia superficial, with a shield; spores one-celled, dark.

Pirostoma nyssae (see *Tubackia dryira*). **Tupelo Leaf Spot**.
Tubackia dryina (formerly *Pirostoma nyssae*). **Tupelo Leaf Spot**.

Placosphaeria

Deuteromycetes, Coelomycetes

Pycnidia globose, dark, in a discoid stroma; spores hyaline, one-celled; teleomorph state in *Dothideales*.

Cheilaria agrostis (formerly *Placosphaeria graminis*). **Tar Spot** on redtop grass.

Placosphaeria graminis (see *Cheilaria agrostis*). **Tar Spot** on redtop grass.

Placosphaeria haydeni. **Black Spot**, **Tar Spot** on goldenrod and aster, stems and leaves.

Laestadia (Plagiostoma)

Ascomycetes, Diaporthales

Spores two-celled, hyaline.

Laestadia asarifolia (formerly *Plagiostoma asarifolia*). **Fruit Rot**, **Early Rot**, **Scald**, **Blast** on cranberry, also blueberry. Small, circular gray spots, with one to six pycnidia in center, have brown margins. The disease is unimportant as a leaf spot; fruits have a hard, dry rot.). **Leaf Spot** on wild ginger.

Mycosphaerella prenanthis (formerly *Plagiostoma prenanthis*). **Leaf Spot** on prenanthis.

Plagiostoma asarifolia (see *Laestadia asarifolia*). **Fruit Rot**, **Early Rot**, **Scald**, **Blast** on cranberry, also blueberry.

Plagiostoma prenanthis (see *Mycosphaerella prenanthis*). **Leaf Spot** on prenanthis.

Pleiochaeta

Pleiochaeta setosa. **Leaf Spot** on Genista

Pleospora

Ascomycetes, Dothideales

Perithecia membranous, paraphyses present; spores muriform, dark; some species have *Alternaria*, some *Stemphylium* as anamorph state; wide saprophytic and pathogenic relationships.

Pleospora herbarum (*Stemphylium botryosum; S. sarcinaeforme*). **Leaf Spot** of clovers, **Leaf Blight** of lilac, **Seed Mold** of China aster and other plants. Spots on legumes are small, irregular, dark brown, sunken, changing to concentric zonated light and dark brown areas. In final stages leaves are wrinkled, dark brown, and sooty. Conidia, like ascospores, are muriform, olivaceous. Annual phlox has tan lesions. Asparagus has purple spots.

Pleosphaerulina (Pringsheimia)

Ascomycetes, Sphaeriales, Dothioraceae

Perithecia innate, not beaked, paraphyses and paraphysoids lacking; spores muriform, hyaline.

Pleosphaerulina sojicola (formerly *Pringsheimia sojicola*). **Leaf Spot** of soybean.

Pseudocercosporella

Pseudocercosporella capsellae. **White Leaf Spot** on mustard greens.

Pyricularia

► Blights.

Pyricularia grisea. **Leaf Spot** on grass

Ramularia

Deuteromycetes, Hyphomycetes

Conidiophores growing out from host through stoma, clustered, short, dark to hyaline; conidia hyaline, cylindrical, mostly two-celled, often in chains; found on living leaves causing leaf spots or white mold.

Cercosporella pastinaceae (formerly *Ramularia pastinaceae*). **Leaf Spot** of parsnip. Lesions are circular, very small, at first brown, then with a white center and brown border. Long, slender, septate, hyaline conidia are produced on exposed conidiophores. No control is necessary.

Entylomella armoraciae (formerly *Ramularia armoraciae*). **Pale Leaf Spot** of horseradish. Few to numerous light green to yellowish spots appear on leaves in early summer, the invaded areas quickly turning thin and papery with dead portions dropping out, leaving ragged holes late in the season.

Innumerable small sclerotium-like bodies in the dead tissue carry the fungus over winter, producing short knobby conidiophores in spring, which either push out through stomata or break through either epidermis. There is no special control.

Ramularia armoraciae (see *Entylomella armoraciae*). **Pale Leaf Spot** of horseradish

Ramularia pastinacae (see *Cercosporella pastinaceae*). **Leaf Spot** of parsnip.

Ramularia primulae. **Primrose Leaf Spot**. Yellow blotches have ash-colored centers.

Ramularia vallisumbrosae. **Narcissus White Mold**, sometimes destructive on Pacific Coast. Small, sunken, grayish or yellow spots appear on leaves, especially near tips, increasing to dark green to yellow-brown patches, on which, in moist weather, spores are formed in white powdery masses. The disease may become epidemic with the foliage killed several weeks before normal ripening. Flower stalks of late varieties may be attacked. Black "sclerotia" winter in leaf fragments on ground, producing spores in spring to infect young shoots.

Control. Spray with bordeaux mixture, starting when leaves are 4 to 6 inches high. Clean bulbs thoroughly after digging and replant in a new location.

Ramularia variabilis. **Foxglove Leaf Spot**. Irregular spots, up to 1/4 inch in diameter, brown with a reddish border, are formed most often on lower leaves. Spores in tufts give a white, moldy appearance.

Ramulispora

Deuteromycetes, Hyphomycetes

Conidia on sporodochia, two- to many-septate, hyaline to subhyaline, oblong to fusoid, irregularly united or branched at base; produced in gelatinous masses.

Ramulispora sorghi. **Copper Spot** of turf grasses, sooty stripe of sorghum, Sudan grass, and Johnson grass. Black superficial sclerotia are formed on both leaf surfaces, with conidia in pinkish gelatinous masses. Spots on leaves are straw-colored with purple borders. Dead areas in turf are small, 1 to 3 inches, copper-red to orange. Velvet bent grass in acid soil is very susceptible. Liming the soil may help.

Rhizoctonia

► Rots.

Rhizoctonia solani. **Leaf Spot** of tobacco, California pepper-tree (Schinus).

Rhytisma

Ascomycetes, Rhytismatales

Apothecia concrete with epidermis and in black, stroma-like spots, tar spots, on leaves; spores filiform, typically hyaline.

Pseudorhytisma bistortae (formerly *Rhytisma bistorti*). **Tar Spot** on polygonum. Black tarry spots similar to those on maple.

Rhytisma acerinum. **Tar Spot** of maple, especially on cut-leaf varieties. Black, thickened, raised, tarlike spots, up to 1/2 inch in diameter, are formed on upper leaf surface. They may be numerous enough to cause some defoliation but ordinarily are more disfiguring than destructive. Red and silver maples are commonly affected in the East. The lesions are light yellow-green at first, forming black stomata in summer along with the conidial stage (*Melasmia acerina*) (see Fig. 3.27). Ascospores are developed in spring in tar spots on fallen overwintered leaves and are forcibly ejected, to be carried by air currents to young leaves overhead.

Control. Collect and burn fallen leaves. Spray in early May with copper, repeating in 3 weeks in an unusually wet season.

Rhytisma andromedae. **Tar Spot** on bog rosemary and lyonia.

Rhytisma bistorti (see *Pseudorhytisma bistortae*). **Tar Spot** on polygonum.

Rhytisma liriodendri. **Leaf Spot** on tulip-tree.

Rhytisma punctatum. **Speckeled Tar Spot** of maple, a black speckled leaf spot on all species but especially on silver, striped, and bigleaf maple in Pacific Coast states, rare in the East. Black, raised specks, pinhead size, are formed in groups on upper leaf surface, in yellow-green areas about 1/2 inch in diameter. Such areas retain their color even after leaves have faded in the fall.

Rhytisma salicinum. **Tar Spot** of willow, on pussy willow and other varieties. Spots are very thick, jet black, definitely bounded, 1/4 inch in diameter. The fungus winters in old leaves which should be raked and burned.

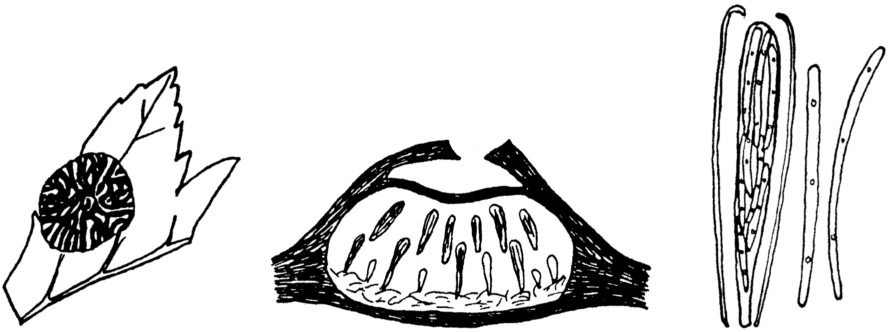


Figure 3.27 Tar Spot of Maple; black tarry spot on leaf; section through spot; ascus, paraphyses, and filiform ascospores

Schizothyrium

Ascomycetes, Dothideales

Brown scutellum or shield, radiate at margin, with a single hymenium underneath; apothecia round to linear, opening with a cleft or lobes; spores hyaline, two-celled.

Schizothyrium gaultheriae (see *Schizothyrium pomi*). **Leaf Spot** on wintergreen.
Schizothyrium pomi (formerly *Schizothyrium gaultheriae*). **Leaf Spot** on wintergreen.

Sclerotinia

► Blights.

Sclerotinia homoeocarpa. **Leaf Spot** on peanut.

Scolecotrichum

Deuteromycetes, Hyphomycetes

Conidiophores in loose clusters, simple, bearing conidia on pushed-out ends of successive new growing points; spores dark, two-celled, ovoid or oblong, often pointed; parasitic.

Cercosporidium graminis (formerly *Scolecotrichum graminis*). **Brown Stripe** of lawn grasses, **Streak** of bluegrass and redtop. Grayish brown to

dark linear streaks on leaf blade may extend into leaf sheath and cause defoliation. Dark gray masses of conidiophores emerge in rows through stomata of upper leaf surface.
Scolecotrichum graminis (see *Cercosporidium graminis*). **Brown Stripe** of lawn grasses, **Streak** of bluegrass and redtop.

Selenophoma

Deuteromycetes, Coelomycetes

Pycnidia brown, globose, immersed, erumpent, ostiolate; conidia hyaline, one-celled, bent or curved, typically crescent-shaped, parasitic.

Pseudoseptoria everhartii (formerly *Selenophoma everhartii*). **Speckle**, **Leaf Blotch** on bluegrass and other grasses. Brown flecks and frog-eye spots on blades in early spring enlarge to straw-colored blotches scattered with minute pycnidia. Spots may drop out, leaving holes.
Pseudoseptoria obtusa (formerly *Selenophorma obtusa*). **Speckle**, **Leaf Blotch** on bluegrass and other grasses. Brown flecks and frog-eye spots on blades in early spring enlarge to straw-colored blotches scattered with minute pycnidia. Spots may drop out, leaving holes.
Selenophoma donacis; Syn. **Pseudoseptoria everhartii** (formerly *S. everhartii*). **Pseudoseptoria obtusa** (formerly *S. obtusa*). **Speckle**, **Leaf Blotch** on bluegrass and other grasses. Brown flecks and frog-eye spots on blades in early spring enlarge to straw-colored blotches scattered with minute pycnidia. Spots may drop out, leaving holes.
Selenophoma everhartii (see *Pseudoseptoria everhartii*). **Speckle**, **Leaf Blotch** on bluegrass and other grasses.
Selenophoma obtusa (see *Pseudoseptoria obtusa*). **Speckle**, **Leaf Blotch** on bluegrass and other grasses.

Septocylindrium

Deuteromycetes, Coelomycetes

Conidiophores hyaline, short and simple or longer and branched, with irregular somewhat inflated cells; conidia hyaline, two- to several-celled, in chains that are sometimes branched; parasitic or saprophytic.

Septocylindrium hydrophylli. **Hydrophyllum Leaf Spot**.

Septogloeum

Deuteromycetes, Coelomycetes

Acervuli subepidermal, erumpent, pale; conidiophores short, simple; conidia hyaline, several-celled, oblong to fusoid; parasitic.

Diplodia acerina (formerly S*eptogloeum acerinum*). **Maple Leaf Spot**. A small leaf spot occasionally defoliating Norway and Schwedler maples in the Middle West.

Cheilaria agrostis (formerly *Septogloeum oxysporum*). **Char Spot** of lawn grasses. Lesions are tawny with yellow margins, circular becoming elliptical, pointed at each end, covered with dull black to brown stromatic tissue.

Septogloeum acerinum (see *Diplodia acerina*). **Maple Leaf Spot**.

Septogloeum oxysporum (see *Cheilaria agrostis*). **Char Spot** of lawn grasses.

Septogloeum parasiticum. **Elm Leaf Spot**, **Twig Blight**.

Septogloeum rhopaloideum (*Guignardia populi*). Grayish brown, circular or irregular spots on poplar.

Septoria

► Blights.

Septoria agropyrina. **Brown Leaf Blotch** on wheatgrasses.

Septoria bataticola. **Sweetpotato Leaf Spot**, occasional, most common in northern tier of sweetpotato states. Minute white spots on leaves are bordered with a narrow reddish zone. Older lesions have one or more pycnidia barely visible to the naked eye. The spores, oozing out in tendrils when water is present on the leaf, are spread by rain and insects. No control is needed except cleaning up crop refuse.

Septoria calamagrostidis. **Leaf Spot** on bent grasses. Scattered gray to straw-colored lesions at tip of blades, appearing in Northwest in late winter and early spring. Seaside creeping bent is especially susceptible.

Septoria callistephi. **Leaf Spot**, **Damping-off**, **Stem Rot** of China aster.

Septoria chrysanthemella and **S. obesa**. **Chrysanthemum Leaf Spot**, also on oxeye daisy, general through eastern and central states to Florida; also reported in the West. This disease is sometimes confused with nematode injury, but the leaf nematode browns the leaves in wedge-shaped areas between veins, and the fungi cause definite spots. These are first small and yellowish, then dark brown to nearly black. Sometimes the spots coalesce into blotches; minute black fruiting bodies are faintly visible. Leaves may turn yellow and drop prematurely or dry and hang down along the stems. Spores are splashed from plant to plant in watering or rain, and are spread on cultivating tools.

Control. Avoid syringing greenhouse plants; do not cultivate outdoor plants, when they are wet.

Septoria citri. **Citrus Septoria Spot** on leaves but more serious on fruits. Small, shallow, light brown depressions on green immature fruit retain a green marginal ring as the fruit colors. Usually a minor trouble, sometimes important in California.

Septoria citrulli. **Watermelon Leaf Spot**. The pathogen is like *S. cucurbitacearum* except that spores are shorter. **Dogwood Leaf Spot**.

Septoria cornicola. Angular lesions between veins are grayish with dark purple margins.

Septoria cucurbitacearum. **Septoria Leaf Spot** of cucurbits, on cucumber, winter squash, muskmelon, and watermelon. Foliage spots are small, gray, circular, rather conspicuous, often bordered with a zone of yellow tissue. The fungus fruits abundantly on upper side of leaves, with long thin septate spores in black pycnidia. It winters in old plant parts; clean up all refuse at end of the season.

Septoria cyclaminis. **Leaf Spot** on cyclamen.

Septoria dianthi. **Septoria Leaf Spot** of Dianthus, on carnation and sweet william. Spots are more or less circular, light brown with purplish brown borders, scattered over leaves and stems, particularly on lower leaves. The spots may enlarge, and the leaves die. Take cuttings from disease-free plants; avoid syringing, or do it early in the day.

Septoria divaricatae (see *Septoria phlogis*). **Septoria Leaf Spot** of phlox.

Septoria gladioli. **Leaf Spot**. More important as a hard rot of gladiolus corms.

Septoria glycines. **Brown Spot** of soybean. Primarily a foliage disease, this may also appear on stems and pods. It starts with irregular brown patches on cotyledons, then reddish brown zones on both sides of leaves, often with pale green or chlorotic zones surrounding the lesions. Spots may cover the whole leaf, defoliation starting from lowest leaves. Brown discolorations with indistinct margins extend an inch or more along stems. The pathogen winters in diseased leaves and in seed. Some varieties are quite resistant. Use healthy seed; treatment is unsatisfactory; rotate crops.

Septoria lactucae. **Septoria Leaf Spot** of lettuce, occasionally destructive to some varieties. Lesions are more common on lower leaves – irregular reddish marks, dotted sparsely with black pycnidia. The fungus is disseminated with seed.

Septoria loligena. **Leaf Spot** on ryegrass, in California. Chocolate brown spots, paler in the center, surrounded by lighter areas.

Septoria lycopersici. **Septoria Leaf Spot** of tomato, **Leaf Blight**, quite destructive in Atlantic and central states, less important in the South and West. In seasons with moderate temperature and abundant rainfall enough foliage is destroyed so that fruits do not mature properly and are subject to sunscald. The disease appears at any age but more often after fruit is set. Infection starts on older leaves near the ground, with small, thickly scattered, water-soaked spots, which become roughly circular with gray centers and prominent dark margins. The spots are smaller, 1/16 to 1/8 inch, and more numerous than those of early blight. Leaflets may die with progressive loss of foliage from the bottom up. The pathogen winters on tomato refuse and solanaceous weed hosts; spores are washed from pycnidia by rain or spread by brushing against moist leaves. Optimum temperature is 60° to 80°F.

Control. Bury plant remains deep in soil or burn; control weeds; use long rotations.

Septoria oudemansii. **Leaf Spot** of bluegrass, in northern states. Dark brown, purple spots turning straw-colored appear on leaf sheaths and spread to blades, with turf turning yellowish brown. Plants may be defoliated in cold wet seasons, but they are rarely killed.

Septoria paeoniae. **Septoria Leaf Spot** of peony, **Stem Canker**. Round gray spots with reddish borders are found on stems and leaves. Control with sanitary measures.

Septoria phlogis (formerly *Septoria divaricatae*). **Septoria Leaf Spot** of phlox. Dark brown circular spots, up to 1/4 inch in diameter, have light gray to white centers and often run together in blotches.

Septoria pistaciarum. **Leaf Spot** on pistachio.

Septoria populicola. **Leaf Spot** of poplar.

Septoria rubi. (Teleomorph, *Mycosphaerella rubi*). **Blackberry Leaf Spot** on blackberry, and dewberry, perhaps with more than one strain. See *Sphaerulina rubi* for forms reported on red raspberry. Leaf spots are light brown, sometimes with a purple border. Infection is usually so late in the season that it is of minor importance, but it may cause some defoliation.

Septoria secalis var. **stipae**. **Leaf Spot** on bent grass. White spots turn straw-colored, with scattered pycnidia.

Septoria spraguei. **Leaf Spot** on Russian wildrye (*Elysum*).

Septoria tageticola. **Marigold Leaf Spot**, reported in 1958 from Florida. Spots are oval to irregular, smoky gray to black, speckled with minute black pycnidia. The disease advances upward from the lower leaves and also infects younger branches, peduncles, bracts, and seed. African marigolds are very susceptible, French almost immune.

Septoria tenella. **Leaf Spot** on fescue grasses. Small, vague, greasy brown spots.

Septoria tritici var. **lolicola**. **Leaf Spot** on ryegrass. Indefinite green to yellow mottled or blotched spots becoming fuscous to deep brown.

Sphaerulina

Ascomycetes, Dothideales

Perithecia separate, innate to erumpent, not beaked, lacking paraphyses and paraphysoids; hyaline, with several cells; clavate-cylindrical.

Sphaerulina rubi (Anamorph, *Cylindrosporium rubi*). **Raspberry Leaf Spot** on red and black raspberry only, common east of the Rocky Mountains. This disease and a similar one on blackberry and dewberry were for many years considered due to *Septoria rubi* and then attributed to *Mycosphaerella* as the teleomorph state. Later it was shown that two species were involved, with *Sphaerulina* the ascomycete on raspberry, *Septoria rubi* the pathogen commonly found on blackberry and dewberry.

Spots are small, circular to angular, first greenish black, then grayish; pycnidia produce elongate, three- to nine-septate spores. Perithecia, formed in fallen leaves, are black, subepidermal, later erumpent; ascospores are cylindrical, curved, pointed at both ends, usually four septate.

Sporonema

Deuteromycetes, Coelomycetes

Pycnidia dark, membranous or carbonaceous, innate, opening with torn lobes; spores hyaline, one-celled.

Sporonema camelliae. **Camellia Leaf Spot**.

Stemphylium

Deuteromycetes, Hyphomycetes

Conidiophores dark, mostly simple, bearing a single terminal conidium or successive conidia on new growing tips; conidia dark, muriform, smooth or spiny; parasitic or saprophytic (see Fig. 3.24).

Stemphylium sp. sp. (Teleomorph, *Pleospora herbarum*). **Red Leaf Spot** of gladiolus, widely distributed, causing an annual loss in Florida since 1938. Spots are small, round, translucent, pale yellow with reddish brown centers. Leaves may be killed before flowering or after spikes are cut, resulting in smaller corms. Infection takes place with 10 hours of dew or fog; rain is unnecessary; optimum temperature is 75°F. Leaves may be killed within 2 weeks of inoculation. Picardy variety is moderately susceptible; it is damaged more severely when grown near very susceptible Stoplight and Casablanca. The disease, starting on particularly susceptible varieties, spreads radially to less susceptible plants, decreasing in severity with distance from focal point. The leaf spot disappears in summer and autumn, reappears in winter 3 weeks after a cold period.

Control. Use resistant varieties to separate very susceptible types from those partly susceptible.

Stemphylium bolickii. **Leaf Spot** of echeveria, kalanchoë, and sedum. On some species lesions are small, raised, irregular to circular, brown to purplish black. On other species spots are larger, with tan centers, purplish margins.

Stemphylium botryosum (Teleomorph, *Pleospora herbarum*). **Leaf Spot**, **Black Seed Rot**, **Seed Mold** on kidney beans, pea, onion, garlic, shallot, salsify, asparagus, pepper, and tomato.

Stemphylium callistephi. **Leaf Spot** of China aster. Brown, nearly circular, concentrically zonate spots with dark margins on leaves, bracts, petals, and stems.

Stemphylium cucurbitacearum. **Leaf Spot** of cucurbits, on cucumbers, muskmelon, and winter and summer squash. The pathogen is possibly secondary, perhaps confused with *S. botryosum*. Small brown spots with lighter centers have mycelium growing over the lesion, producing globose, multiseptate spores.

Stemphylium lycopersici. **Tomato Leaf Spot**. Similar to gray leaf spot but the conidia and conidiophores longer.

Stemphylium solani. **Gray Leaf Spot**, **Stemphylium Leaf Spot** in pepper, tomato, groundcherry, eggplant, and other *Solanum* species, mostly in the South, occasionally a problem elsewhere. In warm, humid weather, plants are defoliated in seedbed or field. First infection is on older leaves, which exhibit numerous small, dark brown spots extending through to the undersurface. Centers are often a glazed gray-brown with cracking and tearing. Leaves turn yellow and wither; all leaves may be killed except those at the top; seedbeds are often destroyed.

Control. Use clean soil for seedbed; spray seedlings at weekly intervals.

Stemphylium vesicarium, **Purple Spot** of asparagus.

Stigmatea (Stigmea)

Ascomycetes, Dothideales

Fruiting structure subcuticular, hymenium a single disclike layer covered with a scutellum; spores dark, two-celled; mycelium scanty.

Hormotheca rubicola (formerly Stigmea rubicola). **Black Spot** of raspberry. Spot formed in late summer with a membranous layer under the cuticle; fruiting bodies produced in spring.

Stigmea geranii. **Black Leaf Speck** of Geranium (cranesbill).

Stigmea rubicola (see *Hormotheca rubicola*). **Black Spot** of raspberry.

Stigmina (Stigmella)

Deuteromycetes, Hyphomycetes

Conidiophores short, dark, with a single terminal spore; conidia dark, muriform but with few cells, ovoid to oblong to nearly spherical; parasitic on leaves.

Exosporium liquidambaris (see *Stigmina liquidambaris*). **Leaf Spot** on sweet gum.

Exosporium palmivorum (see *Stigmina palmivorum*). **Leaf Spot** of palms, in greenhouses and in the South.

Stigmina liquidambaris (formerly *Exosporium liquidambaris*). **Leaf Spot** on sweet gum.

Stigmina palmivorum (formerly *Exosporium palmivorum*). **Leaf Spot** of palms, in greenhouses and in the South. Small, round, yellowish transparent spots run together to form large, irregular, gray-brown blotches; leaves may die. The disease is more serious with insufficient light. Spores are long, club-shaped, brown, with many cells. Remove and burn infected leaves. Spray with bordeaux mixture.

Stigmella platani-racemosae (see *Stigmina platani-racemosae*). **Leaf Spot** of California Sycamore, sometimes causing premature defoliation.

Stigmina platani-racemosae (formerly *Stigmella platani-racemosae*). **Leaf Spot** of California Sycamore, sometimes causing premature defoliation.

Ulocladium

Ulocladium cucurbitae. **Leaf Spot** on cucumber

LICHENS

A lichen is a fungus body, usually one of the Ascomycetes with apothecia, enclosing a green or blue-green alga. The fungus receives some food from the alga and the alga some food and protection from the fungus, a relationship termed symbiotic. Lichens frequently grow on living trees and shrubs, but their injury is indirect, an interference with light or gas exchange to stems or foliage, rather than from penetration of living cells of the suscept plant. There are three types associated with plants: crustose, a crust closely appressed to bark of main trunk or larger limbs; foliose, leaflike, prostrate but not so firmly attached to the substratum; and fructicose, bushlike, erect or hanging.

Lichens are more abundant on garden shrubs – boxwood, camellias, azaleas, and so on – and on citrus in the South. They flourish in neglected gardens and orchards, and in shady damp locations, and may sometimes kill twigs and branches of weak trees growing on poor sites.

In most gardens control is unnecessary. If lichens become too disfiguring or too abundant for plant health, they may be killed by spraying affected parts with bordeaux mixture or other copper spray; spray when the lichens are dry. They may be removed from main trunks by rubbing the bark with a steel brush after they are softened by rain.

MISTLETOE

Mistletoes are seed plants belonging to the family Viscaceae. They are semi-parasites, manufacturing food but depending on a host plant for water and mineral salts. There are three genera in North America: *Phoradendron* and *Viscum* which are true mistletoes, and *Arceuthobium*, dwarf mistletoe.

The mistletoe seed is naked embryo and endosperm invested with a fibrous coat and borne in white, straw-colored, pink, or red fruits – ”berries” – embedded in a sticky gelatinous pulp enabling them to cling to bark of trees or stick to feet and beaks of birds, which disseminate them.

The seeds can germinate almost anywhere but penetrate only young thin bark, by means of a haustorium sent out from a flattened disc. Branches of the haustorium extend up and down and around the tree and occasionally produce secondary haustoria. The number of annual rings on a tree between the tip of the primary haustorium and the bark tells the age of the mistletoe. Many are 60 to 70 years old, and one has been reported as living 419 years.

The aerial portions of mistletoes are leafy, evergreen tufts of shoots on the stems of host plants, most conspicuous on hardwoods after leaf fall (see Fig. 3.28). The stems and leaves contain chlorophyll and are green but often with a yellowish, brown, or olive cast, depending on the season. All species have opposite leaves and round, jointed stems, and are dioecious with inconspicuous petal-less flowers. They occasionally become so large or numerous that the weight of the parasite breaks branches of the host. Growth is slow at first, but in 6 to 8 years the tufts may be 3 feet across. The aerial part does not live much longer than that, but the haustoria live as long as the tree, producing new bunches from adventitious buds.

Because they manufacture their own food, mistletoes require a lot of sun, which may be one reason why they flourish so in the Southwest. Leafy mistletoes are relatively harmless in some situations; in others they handicap shade and forest trees, and occasionally kill hackberries and oaks. There are a few leaf spots and other fungus diseases that keep mistletoes from getting too abundant. They are harvested for Christmas greens with a curved

Figure 3.28 Mistletoe, Common in Southern Trees

mistletoe hook, which can be used to keep aerial portions cut off valuable trees. Breaking off or cutting off the bunches, however, may lead to more shoots in an ever-widening area.

Dwarf mistletoes are far more injurious, especially to forest trees, and much less conspicuous. In western coniferous forests they rank next to heart rots in importance, reducing the quality and quantity of timber and paving the way for bark beetle infestations. Infected branches should be pruned out; if the trunk is infected, the tree should be felled and removed.

Phoradendron (True Mistletoe)

Phoradendron means tree thief. The genus is restricted to the Americas, ranging from southern New Jersey and Oregon southward. Most are on hardwoods.

Phoradendron californicum. **California Mistletoe**, ranging from southern California to Arizona, chiefly on Leguminosae – mesquite, carob, squawbush, creosote bush, parkinsonia. This is a leafless species, generally pendent, with long stems and reddish pink berries.

Phoradendron juniperinum. **Juniper Mistletoe**, a leafless species with straw- or wine-colored berries, ranging from Colorado and Utah through New Mexico and Arizona.

Phoradendron libocedri. **Incense Cedar Mistletoe**, confined to incense cedar and occurring throughout its range in Oregon, California, and Nevada. The pendent plants are leafless with straw-colored berries. It may injure plants severely, causing spindle-shaped swellings in limbs at point of attack and living in the trunk as a parasite for hundreds of years after external portions have disappeared.

Phoradendron serotinum (*flavescens*). **Eastern Mistletoe**, from southern New Jersey west to Ohio and Missouri and south to the Gulf, on many hardwoods – oaks, elm, maple, sycamore, gums, hickory, pecan, hackberry, hawthorn, persimmon, black locust, western soapberry, sassafras, and trumpet-vine. This species has white berries and is the common Christmas mistletoe.

Phoradendron tomentosum. **Texas Mistletoe**, abundant in Texas on elms, oaks, mesquite, osage-orange, and sugarberry; has white berries.

Phoradendron villosum. **Hairy Mistletoe**, ranging from Oregon through California, usually on oaks, also on Oregon myrtle, California buckeye, chestnut, and manzanitas. It has pinkish white berries and may cause large hypertrophies on oaks.

Viscum (True Mistletoe)

The genus is restricted to California. It is now known that Luther Burbank introduced the parasite into the state in about 1900. Burbank's notes indicate that seed was supplied to him by J. C. Vaughan of Chicago, Illinois. This mistletoe has spread about 3.5 miles in 75 years.

Viscum album. **European Mistletoe**, on alder, ash, birch, hawthorn, hickory, buckeye, maple, mountain ash, pear, persimmon, plum, poplar, pyracantha, willow, crabapple, and elm.

Arceuthobium (Dwarf Mistletoe)

The genus is restricted to conifers, and most species are found in the Northwest. Trees of any age may be deformed or killed, but the greatest mortality is among seedlings and saplings, with lodgepole and ponderosa pines most susceptible. The most striking symptom is the formation of witches' brooms, with sometimes the whole crown transformed into a huge broom. In other cases fusiform swellings in trunks turn into cankers. Foliage of affected trees is reduced.

The mistletoes themselves are small, rarely attaining a maximum of 8 inches, sometimes less than an inch. They are pereninal shoots, simple or branched, jointed, with leaves reduced to opposite pairs of scales at the top of each segment. Stems range in color from yellow to brown to olive green. Berries are olive green to dark blue; each contains a single seed, rarely two. The seed is ejected with force and is spread horizontally for some feet. Animals and birds account for infection at a distance.

Arceuthobium americanum. **Lodgepole Pine Dwarf Mistletoe**, common on the Rocky Mountain form but not the Pacific lodgepole pine, found also on fir; rare on other pines. The flowers bloom in spring, accessory branches forming a whorl.

Arceuthobium campylopodum. **Western Dwarf Mistletoe**. It forms witches' brooms and flowers late in summer. Widespread in Northwest principally on coastal ponderosa pine; species that were formerly called *A. campylopodum* are *A. abietinum* on white and grand firs, *A. divaricatum* on pinon pines, *A. laricis* on western larch, *A. microcarpum* on blue and Englemann spruce, *A. tsugense* on western hemlock, *A. cyanocarpum* on limber pine. Found also on exotic pines in California.

Arceuthobium cyanocarpum. **Dwarf Mistletoe** on pine, timber pine, and hemlock.

Arceuthobium douglasii. **Douglas-Fir Dwarf Mistletoe**, confined to this host. Plants are small, only 1 1/2 inches high, greenish, slender.

Arceuthobium occidentale. **Dwarf Mistletoe**, on exotic pines in California.

Arceuthobium laricis. **Dwarf Mistletoe** on fir and hemlock.

Arceuthobium pusillum. **Eastern Dwarf Mistletoe**, the only species in the East, from Minnesota to New Jersey and north to Canada, common on spruce, also on tamarack, and pines. The fruit matures in autumn; shoots are very short, less than an inch.

Arceuthobium tsugense. **Hemlock Dwarf Mistletoe** on western and mountain hemlock. *Colletotrichum gleosporioides* – a hyperparasite.

Arceuthobium vaginatum subsp. **cryptopodum**. **Southwestern Ponderosa Pine Dwarf Mistletoe**. Plant yellowish, robust.

MOLDS

The word mold, or mould, has many meanings. The first one given in Webster is "a growth, often woolly, produced on various forms of organic matter, especially when damp and decaying, by saprophytic fungi." Leaf mold is organic matter reduced to friable earth by these saprophytic fungi. When rhododendrons are fed with a fertilizer having a cottonseed meal base, one can often see a moldy growth, showing that beneficial organisms are at work breaking down the material for plant use.

Some of these saprophytic fungi have a harmful, parasitic phase. The common black bread mold, *Rhizopus nigricans*, causes soft rot of sweetpotatoes and "leak" of strawberries and grapes. *Penicillium* spp., the common blue molds on jellies, cause a decay of citrus and other fruits. Such diseases are discussed under Rots.

The word mold is used loosely to cover any profuse fungus growth on the surface of plant tissue. See Blights for a discussion of Botrytis gray mold, so common on many plants; see Leaf Spots for Alternaria brown molds and Ramularia white molds, and for moldy leaf spots due to *Heterosporium* and *Pleospora*; see Sooty Molds for the black growths on insect exudate; and see Snowmold for turf diseases.

Botryosporium

Deuteromycetes, Hyphomycetes

Conidiophores, tall, slender, hyaline producing numerous lateral branches of nearly equal length, each producing two or more secondary branches that are enlarged at the tip and bear heads of conidia; spores one-celled, hyaline; saprophytic.

Botryosporium pulchrum. **Leaf Mold** on tomato, also geranium (pelargonium), occasional in greenhouses.

Chalara (Chalaropsis)

Deuteromycetes, Hyphomycetes

Mycelium at first hyaline, then greenish; two types of conidia-macroconidia or chlamydospores, olive green, thick-walled when mature, sessile or borne in short conidiophores in compact groups; endoconidia, hyaline, formed inside end cells of a dark endoconidiophore and extruded in chains.

Chalara thielavioides (formerly *Chalaropsis thielavioides*). **Black Mold** of rose grafts. Manetti mold, usually on grafted roses, sometimes on budded roses in nursery fields. The fungus grows over and blackens cut surfaces of stock and scion, preventing union and resulting in death of scions. When outdoor roses are budded on Manetti understock, the bud often turns black and dies. Infection is only through wounds. *Rosa odorata* and *R. chinensis* var. *Manetti* are both very susceptible understocks; *R. multiflora* is moderately susceptible; Ragged Robin is immune.

Control. Use healthy understock. Spray greenhouse benches, tools, etc., with copper sulfate; prevent spread of spores by workmen on hands, clothing, and budding knife.

Chalaropsis thielavioides (formerly *Chalara thielavioides*). **Black Mold** of rose grafts.

Cladosporium

► Blotch Diseases.

Cladosporium fulvum (see *Fulvia fulva*). **Leaf Mold** of tomatoes, general on greenhouse crops, occasionally serious in gardens in wet seasons in the Southeast and sometimes present in other states.

Cladosporium herbarum. **Leaf Mold**, **Pod and Seed Spot**. The fungus is a weak parasite causing black mold of peanut, pod spot and seed mold of lima and kidney beans, glume spot of bluegrass, leaf mold of pepper and tomato, sometimes a fruit mold.

Cladosporium macrocarpum. **Black Mold** of spinach, on old leaves or secondary after other leaf spots.

Fulvia fulva (formerly *Cladosporium fulvum*). **Leaf Mold** of tomatoes, general on greenhouse crops, occasionally serious in gardens in wet seasons in the Southeast and sometimes present in other states. Diffuse, whitish spots on upper surface of older leaves enlarge, turn yellow; the undersurface of the patches has a velvety olive brown coating of spores that are spread by air currents and in watering. Spores remain viable about the greenhouse for several months after plants are removed, and are sometimes carried on seed. Infection occurs only when humidity is high.

Control. Resistant varieties such as Globelle, Bay State, and Vetomold have been developed, but the fungus has mutated to more virulent forms. Regulating ventilators in greenhouses to reduce humidity seems to be the most practical control, sometimes providing heat on cool nights, even in summer.

Melanospora (Erostrotheca)

Ascomycetes, Melanosporales

Perithecia bright, more or less soft, without beak, paraphyses lacking; spores ellipsoid, yellow to olivaceous. Conidial stage has many spore forms.

Erostrotheca multiformis (see *Melanospora multiformis* (Anamorph, *Cladosporium album*)). **White Mold** of sweet pea, **White Blight**, also on perennial pea, observed on greenhouse crops.

Melanospora multiformis (formerly *Erostrotheca multiformis* (Anamorph, *Cladosporium album*)). **White Mold** of sweet pea, **White Blight**, also on perennial pea, observed on greenhouse crops. Leaflets are covered with tan or buff, circular to irregular, small to large spots with cinnamon brown pustules giving a granular appearance. White tufts of mold represent the *Cladosporium* stage. Pseudosclerotia are also formed in the leaves, which may die and drop. The fungus enters through stomata under conditions of high humidity. Dusting with sulfur has been suggested.

Torula

Deuteromycetes, Hyphomycetes

Conidiophores lacking; entire branches of mycelium develop into simple or branched chains of dark conidia, which separate readily; saprophytic.

Periconia maculans (formerly *Torula maculans*). **Leaf Mold** on yucca.

Torula maculans (see *Periconia maculans*). **Leaf Mold** on yucca.

NEEDLE CASTS

Certain diseases of conifers that result in conspicuous shedding of needles are termed needle casts, sometimes needle blights. Most of the fungi causing such symptoms are members of the Phacidiales.

Phaeocryptopus (Adelopus)

Ascomycetes, Dothideales

One of the black mildews, with superficial, dark mycelium; perithecia innate with a central foot, without ostiole; spores two-celled, hyaline.

Adelopus gäumannii (see *Phaeocryptopus gaeumannii*). **Adelopus Needle Cast** of Douglas-fir, **Swiss Needle Cast**.

Phaeocryptopus gaeumannii (formerly *Adelopus gäumannii*). **Adelopus Needle Cast** of Douglas-fir, **Swiss Needle Cast**. Although first noted in Switzerland in 1925, this seems to be a native American disease occurring in relatively harmless fashion on the Pacific Coast, somewhat injurious to native Douglas-fir in the Southwest and to trees in New England and New York. Needles fall prematurely, leaving only the current season's growth. If this happens for several consecutive years, trees have thin foliage, appear yellow or brown, and finally die. Needles are yellow-green to brown, often mottled, and on undersurface tiny black perithecia, issuing from stomata, appear as sooty streaks, one on each side of the middle nerve.

Bifusella

Ascomycetes, Rhytismatales

Apothecia elongate, slitting with a cleft; paraphyses lacking; spores hyaline, one-celled, club-shaped at both ends with halves joined by a narrow neck (Fig. 3.29).

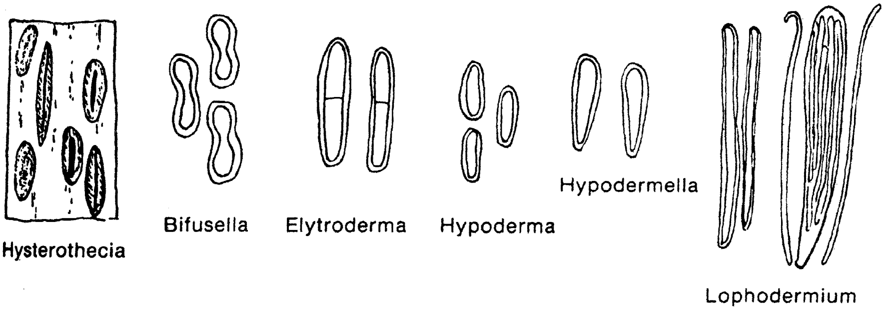


Figure 3.29 Needle Cast Fungi, which form ascospores in hysterothecia, elongate apothecia opening with a cleft. *Bifusella*, spores constricted in middle; *Elytroderma*, fusiform spores; *Hypoderma*, short fusiform spores; *Hypodermella*, spores tapering at base; *Lophodermium*, ascus with filiform spores, and paraphyses

Bifusella abietis (see *Isthmiella abietis*). **Needle Cast** of fir on alpine and corkbark fir from New Mexico to Idaho.

Bifusella faullii (see *Isthmiella faulii*). **Needle Cast** of Balsam fir, the most common and destructive of the needle casts of this host.

Bifusella linearis. **Needle Cast** of pine, **Tar Spot**, on various pine species. Hysterothecia are variable in length, shining black, on two-year needles.

Bifusella saccata. **Needle Cast** on pine.

Isthmiella abietis (formerly *Bifusella abietis*). **Needle Cast** of fir on alpine and corkbark fir from New Mexico to Idaho. Dark brown to black hysterothecia extend the entire length of the middle nerve on undersurface of needle. Pycnidia are in two rows on upper surface.

Isthmiella faulii (formerly *Bifusella faulli*). **Needle Cast** of Balsam fir, the most common and destructive of the needle casts of this host. Ascospores are discharged in July, but infected young needles do not change color until spring, then turn light brown to buff. Effused pycnidia in the same color appear in the groove on upper surface of the needle, followed by dusky brown hysterothecia (apothecia with a covering), with maturing ascospores the second summer.

Canavirgella

Canavirgella banfieldii. **Needle Cast** of pine.

Elytroderma

Ascomycetes, Rhytismatales

Ascospores two-celled, broadly fusiform (Fig. 3.29).

Elytroderma deformans. **Needle Cast**, **Witches' Broom** on Coulter, ponderosa, lodgepole, Jeffrey, pinon, and Jack pines. Elongated dull, dark hysterothecia are on both leaf surfaces. The tissues of ponderosa and Jeffrey pines may be penetrated and loose witches' brooms formed. Saplings may have entire crown converted; they die or make little growth.

Fusarium

► Blights.

Fusarium lateritium. **Needle Cast** on *Torreya taxifolia*.

Hypoderma

Ascomycetes, Rhytismatales

Hysterothecia elliptical to oblong, opening by a cleft; asci long-stalked, spores hyaline, fusiform, surrounded by a gelatinous sheath (see Fig. 3.29).

Hypoderma desmazierii (see *Meloderma desmazierii*). **Needle Cast**, **Tar Spot** of pines, most frequent on eastern white pine.

Hypoderma hedgecockii (see *Ploioderma hedgecockii*). **Needle Cast** of hard pines, in southeastern states.

Hypoderma lethali (see *Ploioderma lethale*). **Gray Blight**, **Needle Cast** of hard pines, from New England to Gulf states.

Hypoderma robustum (see *Virgella robusta*). **Needle Cast** of Firs, in West, usually white fir.

Meloderma desmazierii (formerly *Hypoderma desmazierii*). **Needle Cast**, **Tar Spot** of pines, most frequent on eastern white pine. Infected needles are at first yellow, then reddish brown, and finally deep brown with a grayish cast. The tips are infected first, the fungus being a weak parasite, completing its cycle in a year. Hysterothecia are shining black, elliptical.

Ploioderma hedgecockii (formerly *Hypoderma hedgecockii*). **Needle Cast** of hard pines, in southeastern states. Elliptical shining black hysterothecia are present in discolored areas on green needles. Each ascus contains four normal and four aborted spores.

Ploioderma lethale (formerly *Hypoderma lethaei*). **Gray Leaf Blight**, **Needle Cast** of hard pines, from New England to Gulf states. Hysterothecia are short, narrow, black, often found on pitch pine.
Virgella robusta (formerly **Hypoderma robustum**). **Needle Cast** of Firs, in West, usually white fir. Concolorous pycnidia, which form two rows, one in each needle wing, often turn black after spore discharge.

Hypodermella

Ascomycetes, Rhytismatales

Like *Bifusella* with elongate apothecia, with a cleft, but paraphyses present; spores hyaline, one-celled, club-shaped at upper end, tapering toward base (see Fig. 3.29).
Davisomycella ampla (formerly *Hypodermella ampla*). **Needle Cast** of jack pine. All needles may drop except those of the current season. Short, elliptical, dull black hysterothecia are scattered over light buff-colored areas.
Hypodermella abietis-concoloris (see *Lirula abietis-concoris*). On firs and southern balsam.
Hypodermella ampla (see *Davisomycella ampla*). **Needle Cast** of jack pine.
Hypodermella concolor (see *Lophodermella concolor*). **Needle Cast** of jack pine and lodgepole pines.
Hypodermella laricis. **Larch Needle** and **Shoot Blight** on eastern and western larches. Yellow spots are formed on needles, which turn reddish brown but stay attached, giving a scorched appearance to trees that are normally deciduous. Hysterothecia are very small, oblong to elliptical, dull black, on upper surface of needles.
Hypodermella nervata (see *Lirula nervata*). **Needle Cast** of Balsam.
Lirula abietis-concoloris (formerly *Hypodermella abietis-concoloris*). On firs and southern balsam.
Lirula nervata (formerly *Hypodermella nervata*). **Needle Cast** of Balsam. Pycnidia are in a groove along upper surface of needle in continuous or occasionally interrupted row, turning nearly black after spores are discharged.
Lophodermella concolor (formerly *Hypodermella concolor*). **Needle Cast** of jack pine and lodgepole pines. Virulent fungus infects young needles, in summer, which turn brown the next season. Short hysterothecia are concolorous with the leaf and appear as shallow depressions.

Lirula

Ascomycetes, Rhytismatales

Lirula macrospora. **Needle Cast or Blight** on spruce.

Lophodermium

► Leaf Spots.

Lirula macrospora (formerly **Lophodermium filiforme**). **Spruce Needle Cast**, sometimes causing serious defoliation of red and black spruce. Hysterothecia are long or short, shining black (see Fig. 3.29).

Lophodermium durilabrum. **Needle Cast** on pine.

Lophodermium filiforme (see *Lirula macrospora*). **Spruce Needle Cast**, sometimes causing serious defoliation of red and black spruce.

Lophodermium juniperinum. Widespread and abundant on common juniper and red-cedar but apparently not parasitic. Hysterothecia are elliptical, shining black, on both leaf surfaces.

Lophodermium nitens. Frequent but apparently saprophytic on five-needle pines. Hysterothecia short, black, shining.

Lophodermium piceae. **Needle Cast**, **Needle Blight** of fir, **Tar Spot** on fir and spruce, most severe on young specimens. Needles turn yellow, reddish, or brown, and drop. Short, shining black hysterothecia are formed on all needle surfaces.

Lophodermium pinastri. **Pine Needle Cast**, widespread. Pycnidia appear in spring or early summer as tiny black spots on browned needles, followed by dull, occasionally shining, black, short, elliptical hysterothecia. The fungus is a weak parasite but can be epidemic in nurseries. Bordeaux mixture will control it.

Lophodermium seditiosum. **Needle Cast** of scotch pine.

Mycosphaerella

► Blights.

Mycosphaerella laricina. **Needle Cast** of European larch and western larch.

Cyclaneusma (Naemacyclus)

Ascomycetes, Rhytismatales

Apothecia bright-colored, soft, opening with a cleft; paraphyses much branched; spores worm-shaped.

Cyclaneusma niveum (formerly *Naemacyclus niveus*). **Needle Cast**, occasional on various pines. Fruiting bodies tiny, elliptical, first waxy, dark brown, later concolorous with leaf surface.

Naemacyclus niveus (see *Cyclaneusma niveum*). **Needle Cast**, occasional on various pines.

Pestalotia

► Blights.

Pestalotia microspora. **Needle Spot**, **Cast** of Torreya.

Phoma

► Blackleg.

Phoma eupyrena. **Needle Cast and Blight** of red fir and Douglas-fir.

Rhabdocline

Ascomycetes

Apothecia innate, brown, exposed by irregular rupture of epidermis; paraphyses present; spores one-celled, becoming septate after discharge from ascus, rounded at ends and constricted in the middle.

Rhabdocline pseudotsugae. **Needle Cast** of Douglas-Fir, **Needle Blight**, common on Pacific Coast and in Rocky Mountain States on native Douglas-fir and in northeastern states on ornamental forms. The disease has reached Europe on trees from western North America and is causing much concern there.

Needles are infected in spring or early summer, with first symptoms showing as slightly yellow spots, usually at ends of needles, in autumn or winter. By the next spring the color is reddish brown, and leaves have a mottled appearance. In severe infection needles turn a more uniform brown, and the entire tree appears scorched. Apothecia are usually on underside of needles, sometimes on upper. They are at first round cushions; then the epidermis ruptures to expose a brown, elongated disc. Infected needles drop after ascospore discharge, thereby living only 1 year instead of the normal 8 or so.

Control. Spraying with bordeaux mixture when new needles develop, repeating twice at 10- to 14-day intervals has been suggested; also, spraying with lime sulfur at time of ascospore discharge in early summer. In forests, control will probably depend on early elimination of susceptible trees.

Rhabdocline weirii. **Needle Cast** of Douglas-fir.

Rhizosphaera

Deuteromycetes, Sphaeropsidales, Sphaerioidaceae

Pycnidia brown, on a stalk; spores ovoid, one-celled, hyaline.

Rhizosphaera kalkhoffii. **Needle Cast** of blue spruce. Lowest needles are affected first, becoming mottled yellow, and the disease progresses up the tree. It has been controlled in ornamentals with three sprays of bordeaux mixture.

NEMATODES

In the six decades since the first edition of this book was prepared, nematodes have become of major importance in plant pathology. It used to be stated that plant pests, insects, and diseases, took a toll of one-tenth of all our crops. Now we believe that nematodes alone may cause a 10% crop loss, and some place the figure as high as 25%. The monetary loss is not easy to figure. Guesses range from $500,000 to $8 billion a year in the U.S. Nematodes may be as damaging in home gardens as on farms.

Nematodes used to be considered primarily a southern problem, with the root-knot nematode the major culprit. Now we know that nematodes can be as serious in Maine or Minnesota as in Florida or Texas, and that root-knot species are responsible for only a fraction of total losses.

A 1957 report from Maryland states that samples were taken from around the roots of crop plants on 1210 different farms and gardens, and that every sample included at least one species of nematode known to be a plant parasite, with root-knot nematodes making only 3.2% of the total. A 1959 report from New Jersey states that, on the basis of 2500 soil and root samples taken since 1954, a very conservative estimate of annual loss in the state is $15 million. The root-knot nematodes which are reduced by cold winters, were in third place because of their importance as pests of greenhouse crops, including African-violets, roses, and other ornamentals, as well as vegetable seedlings.

Nematodes (eelworms or roundworms) are threadlike animals in the phylum Nematoda (or Nemata). The following two references were used in the nematode taxonomic descriptions in this section:

Nickle, W. R. 1991. Manual of Agricultural Nematology. Marcel Dekker, Inc., New York, NY. 1035 pp.

Blaxter, M. L., DeLey, P., Garey, J. R., Liu, L. X., Scheldeman, P., Vierstraete, A., Vanfleteren, J. R., Mackey, L. Y., Dorris, M., Frisse, L. M., Vida, J. T., and Thomas, W. K. 1998. A molecular evolutionary framework for the phylum Nematoda. Nature 392 (6671):71–75.

Nematodes live in moist soil, water, decaying organic matter, and tissues of other living organisms. Some cause diseases of man or animals; others cause plant diseases. The animal parasites include hookworms, pinworms, and the worms in pork causing trichinosis, and they range in length from less than an inch to nearly a yard. Most plant parasites are practically microscopic in size, sometimes just barely visible to the naked eye. They mostly range from 0.5 to 2 mm long, or from 1/50 to 1/10 inch.

Nematode diseases of plants are not new. The wheat eelworm was recorded more than two centuries ago (in 1743); root knot has been a recognized problem since 1855. Our systematic investigation of plant parasitic nematodes is very new. Only in the past few years have we made surveys to find out how widespread nematodes are and how many cases of "decline" in plants are due to them. Nematodes injure plants directly by their feeding, causing cell death or gross modifications and general stunting, and indirectly by affording entrance to bacteria and fungi causing rots and wilts. Some nematodes also are vectors of ring spots and other virus diseases.

Many nematodes may merely live in the soil close to the plant and cause no damage, and a few are actually beneficial, feeding on such harmful pests as Japanese beetle grubs. Only an expert nematologist can determine species and decide which are responsible for a plant's ill health. In submitting samples to your experiment station for diagnosis, dig up roots and some surrounding soil, place immediately in a plastic bag to prevent drying out, and mail as soon as possible.

Plant parasitic nematodes may be sedentary or migratory. They do not move through soil to any great distance. Major dispersal is by shipment of infested nursery stock and soil; locally nematodes are spread on tools, and feet, in irrigation water, in plant parts, and sometimes as dry cysts by the wind. Plant nematodes are facultative or obligate parasites. They may be endoparasitic, living inside roots or other tissues, or ectoparasitic, living outside the plant, inserting only the head for feeding; and some forms are intermediate between the two types. Most plant nematodes are root parasites, but some live in stems, bulbs, leaves, or buds. Some cause galls or other distinctive symptoms; others produce a general yellowing, stunting, or dieback that is often ascribed to other causes.

Nematodes are usually long and cylindrical, tapering at both ends, round in cross section. In some genera the female is pear-shaped or saclike, but the male is always vermiform. Nematodes in general lack coloration, being transparent or with a whitish or yellowish tint. They are covered with a cuticle, made up of three main layers,largely protein, under which is a cellular layer called the hypodermis. The body cavity, pseudocoel, is filled with fluid. The body wall musculature, directly beneath the hypodermis, consists of longitudinal fibers only. This means that nematodes cannot contract transversely. They move through moist soil with a threshing motion, or a series of undulations.

Nematodes have a complete digestive tract with a mouth at the anterior end. This is surrounded by lips bearing the sensory organs, but there is no true head, and nematodes lack eyes and nose. Basically there are six lips, but they may be fused in pairs. The sense organs, amphids, are important diagnostic characters, one class of nematodes having amphids with conspicuous openings, the other having amphids with minute pores. Most plant parasitic nematodes belong to the latter group.

Behind the mouth there is a cavity (stoma), then the esophagus, the intestine, and the rectum. The latter terminates in a ventral terminal or subterminal anus in females, in a cloacal opening in males. The sexes are usually separate, but sometimes males are missing and females are hermaphroditic. The body region behind the anus or cloacal opening is called the tail.

Near the posterior end of many nematodes there is a pair of cuticular pouches called phasmids, believed to be sense organs like the amphids. They are used to divide nematodes into two main groups, the Secernentea, or Phasmidia, with phasmids, and the Adenophorea, without phasmids.

All of the plant parasitic nematodes feed by means of a stylet, which works something like a hypodermic needle. It is a conspicuous protrusible spear used to puncture tissue. In most families this is a stomatostylet, a hollow spear derived from the sclerotized walls of the buccal cavity or stoma. Commonly the nematode punctures plant tissue with its stylet, then injects a secretion from its salivary gland that predigests the food before it is sucked in through the stylet. In the family Dorylaimidae the spear is an enlarged tooth, odontostylet, originating in the esophagus wall. It is usually hollow, but in the genus *Trichodorus* the tooth (onchiostyle) is solid but grooved.

The structure of the esophagus varies in different groups and is an important diagnostic character. The esophagus commonly has one or two swellings, known as bulbs. Those provided with a glandular apparatus are true bulbs; those lacking such apparatus are pseudobulbs. True bulbs are the chief pumping and sucking structures. They may be median, situated at midlength, or posterior, at the end of the esophagus.

Control measures for nematodes include crop rotation and other cultural practices and soil treatment with chemicals. Most chemicals are meant for fallow soil; a few are safe around living plants. Details of nematicides and their application are given in ►Chap. 1. Greenhouse soils are often steam-sterilized, and plants are sometimes dipped in hot water, the duration of the soak and the temperature depending on the tolerance of the plant and the kind of nematode to be eradicated. Some plants are antagonistic to nematodes. Asparagus roots produce a chemical that is toxic to many species, and marigolds grown with or in advance of some flower crops reduce the numbers of *Pratylenchus*, lesion nematodes. Some soil fungi trap nematodes but do not provide a practical control. The endospore-forming bacterium *Pasteuria penetrans* is known to effectively suppress certain root-knot nematodes.

Anguina

Anguinidae. Endoparasitic nematodes feeding in above ground plant tissue and transforming seeds or leaves into galls. Males and females both elongate (wormlike), but females are obese. Cuticle finely striated; stylet short with well-developed basal knobs; tail coneshaped; single ovary.

Anguina agrostis. **Grass Nematode**, serious on bent grass and chewings fescue in the Pacific Northwest. Second-stage larvae remain in sheaths near growing tips most of the year, entering embryonic flowers in late spring. There the larvae mature, and the females lay large quantities of eggs. The quickly hatching young larvae transform developing seed into elongated dark purple galls. When the galls fall to the ground, nematodes are released to reinfect grass in the vicinity. There is only one generation a year, and larvae cannot exist in moist soil more than a year without access to a host plant with developing inflorescence. The disease is important only on grass grown for seed; it is not a problem on clipped turf. When seed is threshed, galls can be carried 300 feet or more from the machines by air currents, and still further in heavy winds.

Control. Rotate with a crop other than bentgrass or fescue or plow under and prevent inflorescence for 1 year. Soak seed for 2 hours in tepid water with a wetting agent; then hold for 15 minutes at 126°F.

Anguina balsamophila. On balsam-root; galls on underside of leaves.

Anguina graminis. Galls on leaves of fescue grasses.

Anguina tritici. **Wheat Nematode** on wheat and rye, a field crop pest forming galls in place of grain. The disease was recognized in 1745, the first to be attributed to nematodes. The species is long-lived, viable nematodes having been found in seed stored 28 years. Brine flotation was the old method of eliminating galled seed.

Aphelenchoides

Aphelenchoididae. Bud and leaf nematodes, foliar nematodes. Ecto- and endoparasites; males and females wormlike, very slender; cuticle finely annulated; stylet with small basal knobs; tail with acute tip.

Aphelenchoides besseyi (including *A. oryzae*). **Summer Dwarf Nematode** of strawberry, present from Maryland to Louisiana, also reported from Oklahoma, Missouri, southern Illinois, California, and Washington. The nematodes live in the soil and are washed into buds by rains and irrigation water, affecting young leaves as they develop. Leaflets are crimped or crinkled, cupped, narrow, with a reddish cast to veins and petioles. Older leaves are darker green, more brittle than normal. This is a major disease in Florida, commonly noted from July to October. Cold weather checks its progress often masking symptoms, but plants do not recover; runner plants from infested mother plants are diseased. In spring the nematode population may be low, allowing nearly normal formation of early leaves, but in summer a single bud may harbor up to 1300 individuals, causing center leaves to be deformed and dwarfed. The same species causes a serious disease of rice in Arkansas and Louisiana.

Control. Buy certified plants; rogue and burn diseased plants as soon as noticed. Treat dormant infested plants with hot water, 2 minutes at 127°F.

Aphelenchoides fragariae (including *A. olesistus*). **Spring Dwarf Nematode** of strawberry; **Fern Nematode**, a leaf nematode. A bud parasite of strawberry from Cape Cod to Maryland and found in scattered localities along the Pacific Coast. This is a cold-weather species, persisting through the winter with several thousand nematodes present in a single bud as leaves unfold in spring. The foliage is small twisted, thickened, glossy, with swollen petioles; blossom buds are killed or poor, and no fruit is set. Some plants are killed; others recover.

As the fern nematode, or begonia leaf blight nematode, this species is recorded on anemone, aquatic plants (*Cabomba* sp., *Limnophila* sp., *Peplis* sp., and

Potamogeton sp.), begonia, bouvardia, calceolaria, chrysanthemum, clematis, coleus, crassula, dianthus, doronicum, fern, geranium, hosta, hydrangea, Lamium, lily, peony, primrose, saintpaulia, scabiosa, zinnia, and other ornamentals. Fern leaves have a patchy or blotched appearance with dark brown to black areas on the fronds. In some species these are rather narrow dark bands from midrib to border, limited by parallel side veins; in bird's-nest fern there is a profuse brown discoloration from the base halfway up the leaf.

On begonias the disease is most serious on semituberous varieties grown in greenhouses. Small brown spots with water-soaked margins, on underside of leaves, enlarge, coalesce, turn dark brown, and become visible on the upper surface. Whole leaves may turn dark; plants may be stunted. On fibrous-rooted begonias spots stay small, and leaves become shiny with a tendency to curl, lose color, and drop. Nematodes are spattered from plant to plant by syringing or careless watering; there is no disease spread when foliage is kept dry.

Dieback of Easter lilies grown in the Northwest is also attributed to this bud and leaf nematode. Leaves are first blotched with yellow, then turn brownish, drooping and curling against the stem (see Fig. 3.30). The nematodes live over in the bulbs and are splashed from leaves of one plant to another in the field. Lilies from diseased bulbs develop "bunchy-top" symptoms, with thick, twisted foliage and dieback.

Control. Strawberry plants in nurseries should be inspected and certified in spring. Mother plants, near the end of the dormant period, can be treated with hot water, 2 minutes at 127°F. Crop rotation helps.

Bulbs may be treated with hot water, for 1 hour at 111°F. Potted begonias can be submerged, pot and all, for 1 minute at 120°F, or for 3 minutes at 116°F. African violets may be treated for 30 minutes at 110°F, ferns for 10 to 15 minutes at the same temperature.

Aphelenchoides parietinus. Causing root-plate and scale necrosis of bulbous iris.

Aphelenchoides ritzemabosi. **Chrysanthemum Foliar Nematode**, common and serious on this host in home gardens and greenhouses, first reported in New Jersey in 1890. It is also recorded on dahlia, zinnia, and some other ornamentals but possibly confused with *A. fragariae*. A morphologically similar species produces a yellow bud blight of Vanda orchids. The first symptoms are dark spots on areas on underside of leaves, but by the fifth day after infestation discolored veins stand out sharply on upper leaf surface, and

Figure 3.30 Foliar Nematode on Lily

diseased leaves turn brown or black, starting in distinctive wedge-shaped areas between veins (see Fig. 3.31). Later the leaves dry, wither, and hang down along the stems. The nematodes swim from the soil up the stem in a film of water, the disease going from lowest leaves progressively upward. Almost any variety may be attacked, but Koreans are particularly susceptible. The nematodes may not survive the winter in old dead leaves but they do survive in living leaves in old crowns.

Control. Keep foliage dry; avoid overhead watering. Use a mulch to avoid splashing. Avoid crown divisions; make tip cuttings which are usually free from nematodes. Dormant plants can be treated with hot water, 5 minutes at 122°F or 30 minutes at 112°F.

Figure 3.31 Leaf Nematode of Chrysanthemum. Wormlike male and female nematodes cause wedge-shaped browning between veins, followed by general blighting of leaf

Aphelenchoides ritzemabosi. **Current Nematode**, a bud parasite on black currants and gooseberries in England; reported from California on gooseberries. Treat cuttings for 30 minutes in hot water, 110°F.

Aphelenchoides subtenuis. **Bud and Leaf Nematode** on narcissus, causing scale necrosis. Reported from the Southeast and Pacific Coast states.

Belonolaimus

Belonolaimidae. Sting nematodes, migratory obligate ectoparasites, usually found free in soil near growing tips; both sexes long, slender, with blunt ends; body strongly annulate; about 2 mm long, stylet long, with well-developed knobs; two ovaries.

Belonolaimus gracilis. **Sting Nematode** on a wide variety of hosts from Virginia southward, also reported from New Jersey and from a rose greenhouse in Connecticut. This is a major pest of strawberries, celery, and sweet corn in Florida. It injures Bermuda, centipede, and St. Augustine grasses and seedlings of slash and long-leaf pines, being first recorded from pine. Other plants damaged by *Belonolaimus* species include peanut, pea, lupine, Austrian winter pea, cowpea, bean, lima bean, soybean, beets, cabbage, cauliflower, lettuce, endive, onion, potato, and sweetpotato. The slender worms feed at root tips and along the sides. Soil fungi enter roots through feeding punctures. Roots develop short stubby branches with necrotic lesions; plants are stunted. On woody plants decline symptoms include chlorosis, twig dieback, premature dropping of fruit (such as grapefruit), and rapid wilting under moisture stress. The nematodes seem to be limited to light, sandy soils.

Control. Rotate crops; cultivate to remove weed hosts.

Belonolaimus longicaudatus. This species may be responsible for some of the injury ascribed to *B. gracilis*. It occurs in the same southeastern states and may injure roots of celery, peanut, grasses, cabbage, bean, and other vegetables. Potato and soybean are considered especially susceptible. It has also been reported on magnolia.

Bursaphelenchus

Aphelenchoididae. Ecto - and endoparasites; females (adult) have a vulval flap.

Bursaphelenchus lignicolus. Causes wilt of pine and the nematode is vectored by cerambycid beetle (pine sawyer beetle).

Bursaphelenchus xylophilus. **Pinewood Nematode** on pine.

Cacopaurus

Tylenchulidae. Cuticle finely annulate; female small but very obese; eggs large; male lacks stylet.

Cacopaurus pestis. Reported from roots of Persian (English) walnut in California, causing typical decline with reduction in size and number of leaves, fewer nuts, eventually complete defoliation and death.

Criconema

Criconematidae. Ring nematodes, short, thick, sedentary ectoparasites; cuticle thick with spines or scales; usually found in woodlands, in damp areas, seldom in cultivated soil.

Criconema civellae. Reported on citrus roots in a Maryland greenhouse.

Criconema decalineatum. **Fig Spine Nematode** on figs.

Criconema spinalineatum. **Zoysia Spine Nematode** on Zoysia.

Mesocriconema

Criconella xenoplax (see *Mesocriconema xenoplax*). **Ring Nematode** on peach cover crops including curly dock, perennial ryegrass, vetch, crimson clover, hairy vetch, and cowpea; also tall fescue, and white clover.

Mesocriconema xenoplax (formerly *Criconella xenoplax*). **Ring Nematode** on peach cover crops including curly dock, perennial ryegrass, vetch, crimson clover, hairy vetch, and cowpea; also tall fescue, and white clover.

Criconemoides (Genus dubium)

Criconematidae. Ring nematodes; short, thick-bodied; cuticle thick with retrose (inclining backward) annules; ectoparasites with a wide host range

Criconemoides annulatum. On holly oak, Montana; beans and citrus, Louisiana.
Criconemoides citri. **Citrus Ring Nematode** on citrus in Florida. The broadly annulated head is often buried deep in root tissue, which dies near the feeding puncture.
Criconemoides crotaloides. On Douglas-fir and poplar, Utah.
Criconemoides curvatum. Reported in large numbers on carnations but apparently not very injurious; also on grasses, Ohio.
Criconemoides cylindricum. On peanut, in Georgia.
Criconemoides komabaensis. On camellia, in Florida.
Criconemoides lobatum. On pines, Florida; potato, New York; also grasses.
Criconemoides mutabile. On marigold, D.C.
Criconemoides ornatum. On grasses, Ohio.
Criconemoides parvum. On grasses, Ohio.
Criconemoides rusticum. On grasses, Ohio.
Criconemoides similis. **Cobb's Ring Nematode**. Apparently an important factor in decline of peaches in Maryland and North Carolina, reported on pine in Florida and North Carolina.
Criconemoides teres. On oak, California.
Criconemoides xenoplax. On carnation, causing reduced root system, stunting, reduced flower yield; also reported on grape, peach and grasses.

Crossonema

Crossonema sp. **Decline** of Alaska cedar.

Ditylenchus

Anguinidae. Bulb and stem nematodes, slender, of moderate length, conelike tail, finely striated cuticle, mostly endoparasites.

Ditylenchus destructor. **Potato Rot Nematode**. Feeding on underground stem structures of a large number of plants but important on potato, especially in Idaho and Wisconsin. Discolored spots on tubers progress to a gray or brown decay. The tissues have a granular appearance; they dry and shrink and the skin may crack. Invasions continue in storage, sometimes with complete destruction of tubers.

Ditylenchus dipsaci. **Stem and Bulb Nematode**. An internal parasite of bulbs, stems, leaves, rarely roots, causing Eelworm Disease of Narcissus, Ring Disease of Hyacinth, Onion Bloat, Stem Disease of Phlox. The name *dipsaci* covers many strains and probably more than one species. The type was found in 1857 on Fuller's teasel. The nematodes are thought to release a pectinase during feeding, which results in a dissolution of the middle lamella and the production of large intercellular spaces. They injure, besides hyacinth and narcissus, grape-hyacinth, tulip, galtonia, garlic, shallot, and onion, and cause a stem disease of alfalfa and many flowers besides phlox.

The strains of hyacinth and narcissus are not reciprocally infective, although the hyacinth strain does infect onions. Hyacinths have yellow flecks or blotches on the leaves, which are often twisted, short, and split. In narcissus there are pustules or blisters, called spikkels, in leaves, which can be felt when the leaf is drawn through the fingers. Nematodes in such pustules probably enter leaves as they push up through the soil. Bulbs badly diseased at planting produce no foliage, or a few leaves that are premature, twisted, and bent.

When leaves are dry, nematodes are inactive; but when the foliage is moist and decayed, they revive and pass down into the soil or the neck of the bulb. They enter bulb scales, move down to the basal plate, and then enter the base of other scales. Infected scales are brown, and, since there is little lateral movement of nematodes, the cut surface of a bulb shows one or more brown rings contrasting with healthy tissue. Eggs, larvae, and adults are all present in the brown areas. Male and female adults are wormlike, up to 1.9 mm long. Infective larvae issue in large numbers in whitish tufts in a break between basal plate and scales, and work through the soil to invade adjacent plants.

They are also spread in irrigation water, on tools, and by animals. Some winter in weed hosts, some in seed of composites. In moist soil they die in a year or so, but they have been recovered from plants after 5 or 6 years.

The strain on phlox attacks campanula, sweet william, evening primrose, goldenrod, schizanthus, anemone, foxglove, and orchids. The leaves are very narrow, crinkled, and waved, often brittle, with a tendency to lengthen petioles. Stems may be swollen near the top or bent sidewise; plants are stunted, often fail to bloom, may die prematurely. The nematodes enter through stomata of young shoots and work upward as the stems develop. They infest seed of phlox and other composites, and may be so disseminated.

In onions the inner bulb scales are enlarged, causing a split onion that seldom flowers and sometimes rots at the base. Seedlings are twisted, stunted, covered with yellow spots. On plants grown from sets, a slight stunting and flaccid condition of outer leaves is followed by leaf-tip necrosis and continued stunting. The larvae may live long in infested soil and may be carried in set onions.

Control. Commercial growers routinely treat narcissus bulbs in hot water, 4 hours at 110° to 112°F. All infected plants, parts, and debris should be removed from fields and destroyed; a 2- to 4-year rotation may be tried. Take up and burn infested phlox or similar plants. Put new plants in a new location or in fumigated soil.

Ditylenchus (Sychnotylenchus) gallicus. On elm.

Ditylenchus iridis. Probably a strain of *D. dipsaci*, on bulbous iris. Mildly infected plants dry up prematurely and have poor root systems. Heavily infected plants are stunted, having few if any roots, and the bulbs decay before harvest. Treat bulbs with hot water as for narcissus, but soak only 3 hours and as soon after curing as possible.

Dolichodorus

Dolichodoriadae. Awl nematodes similar to sting nematodes with long stylet with well-developed knobs; coarsely annulated cuticle; both sexes wormlike; male tail has a bursa (lateral extension); female has two ovaries; ectoparasites.

Dolichodorus heterocephalus. **Awl Nematode**, causing decline of celery, bean, tomato, corn, pepper, and water chestnut in the Southeast, also recorded on pecan. It feeds largely on root tips and sometimes along the side of roots, causing necrotic lesions. It also feeds on germinating seeds and hypocotyls, sometimes penetrating the seedcoat to reach the embryo. Poor seedling emergence may be due to this nematode.

Dolichodorus (Neodolichlodorus) obtusus. On arctostaphylus and pecan, California.

Dorylaimus

Dorylaimidae. Spear nematodes, with an odontostylet (hollow tooth), bottle-shaped esophagus; cuticle with longitudinal ridges; both sexes wormlike, tails rounded to cone-shaped; not proven plant parasites.

Dorylaimus spp. Found in soil near soybean, sweetpotato, and other plants but not known as a pathogen.

Helicotylenchus

Hoplolaimidae. Spiral nematodes, ectoparasites or semiendoparasites; long strong stylet with basal knobs; cuticle annulated. The head is inserted in a root, but the body remains outside in a ventrically curved spiral with one or more turns.

Helicotylenchus dihystera. On gardenia, corn, and bluegrass.

Helicotylenchus erythrinae. **Zimmerman's Spiral Nematode**. Rather common in Florida around roots of grasses. Present in other states on blueberry, boxwood, cauliflower, cedar, clovers, corn, cranberry, turf grasses, oak, oat, pachysandra, pepper, pieris, pine, rhubarb, soybean, strawberry, wheat, and yew.

Helicotylenchus multicinctus. **Cobb's Spiral Nematode**. Associated with roots of many plants, including azalea, cherry, cranberry, marsh grass, hibiscus, peach, pine, spruce, and yew.

Helicotylenchus nannus. **Steiner's Spiral Nematode**, a small species common in the Southeast. Found damaging roots of apple, azalea, boxwood, asparagus fern, calathea, camellia, centipede grass, civet bean, gardenia, peperomia, philodendron, rubber-plant, royal palm, laurel oak, soybean, peanut, and tomato. There is a gradual decline, stunting, and failure to form flower buds.

Helicotylenchus pseudorobustus. On corn, grape, tomato, and soybean.

Hemicriconemoides

Criconematidae. Ectoparasites; female with cuticular sheath, anchor-shaped stylet with anteriorly concave knobs; males without sheath or stylet. Commonly associated with turf and woody plants in warm climates, but pathogenicity not yet demonstrated.

Hemicriconemoides biformis. **Oak Sheathoid Nematode**. On roots of oak, Florida.
Hemicriconemoides chitwoodi. Associated with stunting of camellias.
Hemicriconemoides floridensis. **Pine Sheathoid Nematode**. On pine.
Hemicriconemoides gaddi. On camellias.
Hemicriconemoides wessoni. On myrica, Florida.

Hemicycliophora

Criconematidae. Sheath nematodes; ectoparasites with sedentary habits; female retains last molt as an extra cuticle; knobs of stylet spheroid; males rare, without stylet.

Hemicycliophora arenaria. Causing root galls on rough lemon, also reproducing in tomato, pepper, celery, squash, and bean. Celery has large, multibranched galls.
Hemicycliophora brevis. On California-laurel.
Hemicycliophora obtusa. On beet, Utah.
Hemicycliophora parvana. **Tarjan's Sneath Nematode**, damaging celery in Florida, also recorded on corn, beans, and dracaena.
Hemicycliophora similis. **Grass Sneath Nematode**. Also causes small galls on roots of blueberry and cranberry.

Heterodera and Globodera

Heteroderidae. Cyst nematodes, highly specific, attacking members of but few genera in a given plant family, partially endoparasitic, quite sedentary, attached to root by neck only. The female is lemon-shaped to globoid, white, yellow, or brown, 0.5 to 0.75 mm. Eggs are deposited or retained in body of mother, whose leathery wall forms a true cyst. Eggs remain alive for years in cysts, which are spread by wind or in soil around nonhost plants. Males are slender worms, up to 1.75 mm. Root-knot nematodes, formerly all classed as *Heterodera marioni*, have been reclassified as various species of *Meloidogyne*. The stylet *Heterodera* is twice as long as that in *Meloidogyne*, and the latter does not form true cysts.

Globodera rostochiensis (formerly *Heterodera rostochiensis*). **Golden Nematode** on white potatoes, also eggplant, tomato, and other members of the Solanaceae, but not on tobacco. It was first discovered in the United States on Long Island in 1941, and it was kept there, by a rigorous quarantine, until 1967, when it was found at a single location in upstate New York. In 1968, it was found on a potato farm in Delaware. Known as "potato sickness," the disease has been serious in the British Isles for many years. Crops do not show much damage until heavy populations have built up in the soil; then there is midday wilting, stunting, poor root development, early death, with up to 85% reduction in potato yield. The eggs live in the soil inside cysts barely visible to the naked eye. Each may contain up to 500 eggs, and some hatch one year, some another. Cysts have remained viable 17 years. In spring, when soil temperature is around 60°F, a chemical given off by potato or tomato roots stimulates hatching, and the larvae (which have had a first molt inside the egg) leave the cysts and migrate to host plants, entering the roots. The females become stationary, swell to pear shape, and break through the roots, remaining attached by a thin neck. The cylindrical males work out of the roots and cluster around to mate with the females. Eggs are formed, and the dead female becomes the cyst, first white, then gold, orange, finally brown. Cysts detached from roots remain in the soil or may be spread in potato bags, crates, machinery, even in trouser cuffs of farm workers. Lily-of-the-valley pips, cacti, and other plants intercepted at quarantine have had golden nematode cysts in fragments of soil around the roots.

Control. A quarantine restricts movement of potatoes, nursery stock, root crops and top soil from infested land. Healthy potatoes are sold in paper bags to prevent reinfestation from secondhand burlap bags. The Peconic strain of potato is said to be resistant; Rosa, Elba, and NY 71 are also resistant.

Heterodera avenae. **Oat Cyst Nematode** on pea.

Heterodera cacti. **Cactus Cyst Nematode**. Obtained from various localities in Mexico, where it is probably indigenous, and likely to occur on cacti wherever grown. The cyst is lemon-shaped.

Heterodera carotae. **Carrot Cyst Nematode**.

Heterodera cruciferae. **Cabbage Cyst Nematode**, closely related to the sugarbeet nematode. On crucifers in California. Hosts include broccoli, Brussels sprouts, cabbage, cauliflower, kale, kohlrabi, mustard, radish, rutabaga, seakale, lobularia, sweet alyssum, wallflower, and garden cress.

Heterodera fici. **Fig Cyst Nematode** on fig in Florida and California.

Heterodera glycines. **Soybean Cyst Nematode** causing Yellow Dwarf Disease. An immigrant from Japan and Korea, first noted in North Carolina in 1954, thence spread to Arkansas, Florida, Illinois, Kentucky, Louisiana, Mississippi, Missouri, Tennessee, and Virginia. Plants are yellow, stunted; roots are small and dark with few or no bacterial nodules but with lemon-shaped brown cysts clearly visible. This nematode reproduces only in roots of lespedeza, vetch, tomato and bean, besides soybean, but the cysts occur as contaminants of narcissus bulbs and gladiolus corms grown in infested soil and may be so disseminated.

Infested areas are under federal and state quarantines. Soil fumigation temporarily reduces nematode populations and increases plant growth and yield.

Heterodera gottingiana. **Pea Cyst Nematode** on pea.

Heterodera humuli. **Hop Cyst Nematode** on bean, pea, and cucumber.

Heterodera iri. On grasses.

Heterodera mothi. **Cyst Nematode** on nutsedge.

Heterodera punctata (*Punctodera punctata*). **Grass Cyst Nematode** found on wheat and small grains, also associated with bentgrasses in North Dakota, Michigan, and Minnesota, and turfgrass in New Jersey.

Heterodera rostochiensis (see *Globodera rostochiensis*). **Golden Nematode** on white potatoes, also eggplant, tomato, and other members of the Solanaceae, but not on tobacco.

Heterodera schachtii. **Sugar Beet Nematode**, occurring in sugar-beet areas from California to Michigan, also infesting table beets and crucifers – cabbage, broccoli, rape, turnip, rutabaga, and radish. The females, numerous white specks clinging to roots, contain 100 to 600 eggs. Slender larvae puncture root cells with their strong stylets and pass through three molts inside the roots. The wormlike males then leave the roots to search for the flask-shaped females, which are attached to the roots only by their heads. Eggs are deposited in a gelatinous mass. These soon hatch to start other generations, but the females die with more eggs inside their bodies, which turn brown and become cysts. Eggs inside cysts may remain viable 5 or 6 years. Control depends on a very long crop rotation or soil fumigation.

Heterodera tabacum ((*Globodera tabacum tabacum*). **Tobacco Cyst Nematode**. Reported from Connecticut on tobacco, tomato, and other solanaceous plants, but not potato; also reported on Jerusalem-cherry, eggplant, and pepper in Virginia. Stunting is also caused on tobacco.

Heterodera trifolii. **Clover Cyst Nematode**. On clover and other legumes except peas. Spinach, beet, soybean, and carnation are minor hosts. Cysts are brown, lemon-shaped.

Heterodera zeae. **Corn Cyst Nematode**. On sweet corn, field corn, and barley.

Hoplolaimus

Hoplolamidae. Lance nematodes, somewhat migratory, some species tropical or subtropical, of moderate length; strong stylet with basal knobs; often in a spiral or C-shape position.

Hoplolaimus coronatus. On Nerine, grasses, carnation, oak, citrus, pine, sweetpotato, and tomato.

Hoplolaimus galeatus (*H. coronatus*). **Crown-Headed Lance Nematode**, wide-spread. On turf grasses, zoysia, nursery crops, corn, sugarcane, citrus, tomato, sweetpotato, pine seedlings, and carnation. This species may feed from the outside, burying the head only, or it may enter the root completely, destroying the cortex, which is sloughed off, and feeding on the phloem.

Hoplolaimus magnistylus. **Stunt** on hibiscus.

Hoplolaimus uniformis. On various ornamentals, reported from Rhode Island.

Hypsoperine

Heteroderidae. Similar to *Meloidogyne*, the root-knot nematode, but female body oval rather than pear-shaped.

Hypsoperine graminis. Described in 1964 from roots of grass and forming inconspicuous galls, primarily on members of the Gramineae. St. Augustine grass may become chlorotic and die. Bermuda grass may decline. Also present on zoysia.

Longidorus and Paralongidorus

Longidoridae. Needle nematodes; relatively large ectoparasites with long, slender stylet; similar to *Xiphinema* but not causing galls.

Longidorus elongatus. On grape, causing necrosis and excessive root-branching.
Longidorus maximus. Reported associated with celery, leek, lettuce, and parsley.
Paralongidorus sylphus. **Thorn's Needle Nematode**, fairly common in the Pacific Northwest, causing severe stunting of peppermint.

Meloidodera

Heteroderidae. A new genus, a link between *Heterodera* and *Meloidogyne*; eggs are retained in the female, but there is no distinct cyst stage; second stage larvae invade roots but no galls are formed.

Meloidodera floridensis. In roots of slash pine in Florida.

Meloidoderita

Tylenchulidae sp. On grapes. Males developed in soil and have a degenerate esophagus that lacks a stylet.

Meloidogyne

Heteroderidae. Root-knot nematodes, formerly considered one species, now known to be several, distinguished by slight morphological differences such as striations, perineal pattern of the tail, type of galls formed, host preferences, and somewhat by locality. Females are white, pear-shaped to sphaeroid with elongated necks, slender stylets with well-developed basal knobs; males are slender, wormlike. Females deposit eggs in a gelatinous mass, and the body is not turned into a cyst as in *Heterodera* (see Fig. 3.32).

Root knot is the best known nematode disease, with over 2000 plant species susceptible to one or more forms of Meloidogyne. Root knot was first reported in England, in 1865 on cucumbers; in 1876 it was recorded in the United States on violet. Infected plants are stunted; they often wilt, turn yellow, and die. The chief diagnostic symptom is the presence of small or large swellings or galls in the roots (see Fig. 3.33). They are nearly round or long and irregular, but they are an integral part of the root and cannot be broken off. This differentiates them from beneficial nodules, formed

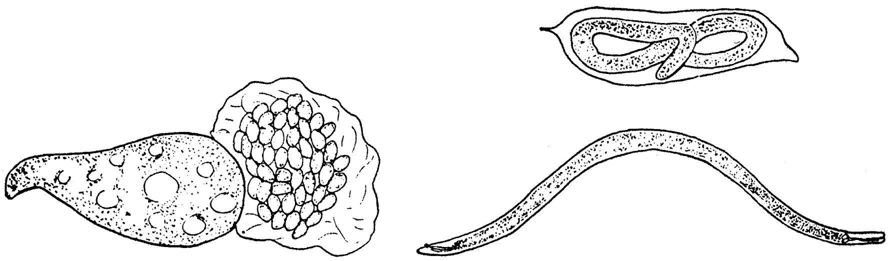


Figure 3.32 Root-Knot Nematode Galls on Potato

on legume roots by nitrogen-fixing bacteria, which can be readily broken off.

Root-knot nematodes occur in practically every state. We used to think they were killed by northern winters, but some species can survive extreme cold. They do have fewer generations in the North and do not build up such large populations as in southern sandy or peat soils. Grasses and grains are about the only plants immune or resistant to root knot.

The long, thin young larva takes form inside the egg, breaks out, and migrates through the soil to a root. It moves in to the axial cylinder and there becomes sedentary. It injects a secretion of its esophageal glands into the tissue by means of its short buccal stylet, and this stimulates the formation of 3 to 5 giant cells around the injection point. The nematode absorbs its food from these nectarial cells the rest of its life. As it feeds, the larva swells rapidly into a sausage-shaped body, which, in the female, becomes whitish and pear-shaped, large enough to be just visible to the naked eye. The male changes into a threadlike cylindrical form, folded up inside the larval molt, from which it finally escapes.

The female deposits its eggs in an extruded yellow-brown jelly. There may be up to 3000; the average is nearer 300 to 500. The larvae develop inside the eggs and become free in the soil when the host root cracks or decays. They may attack the same root in a new place or another root. At 80°F a generation takes only 25 days; at 67°F the cycle averages 87 days, and below 55°F activity ceases. Root-knot nematodes may be injurious by their feeding punctures even if typical swellings are not formed. Some have been shown to increase Fusarium and bacterial wilts, and they almost surely complicate the crown-gall problem.

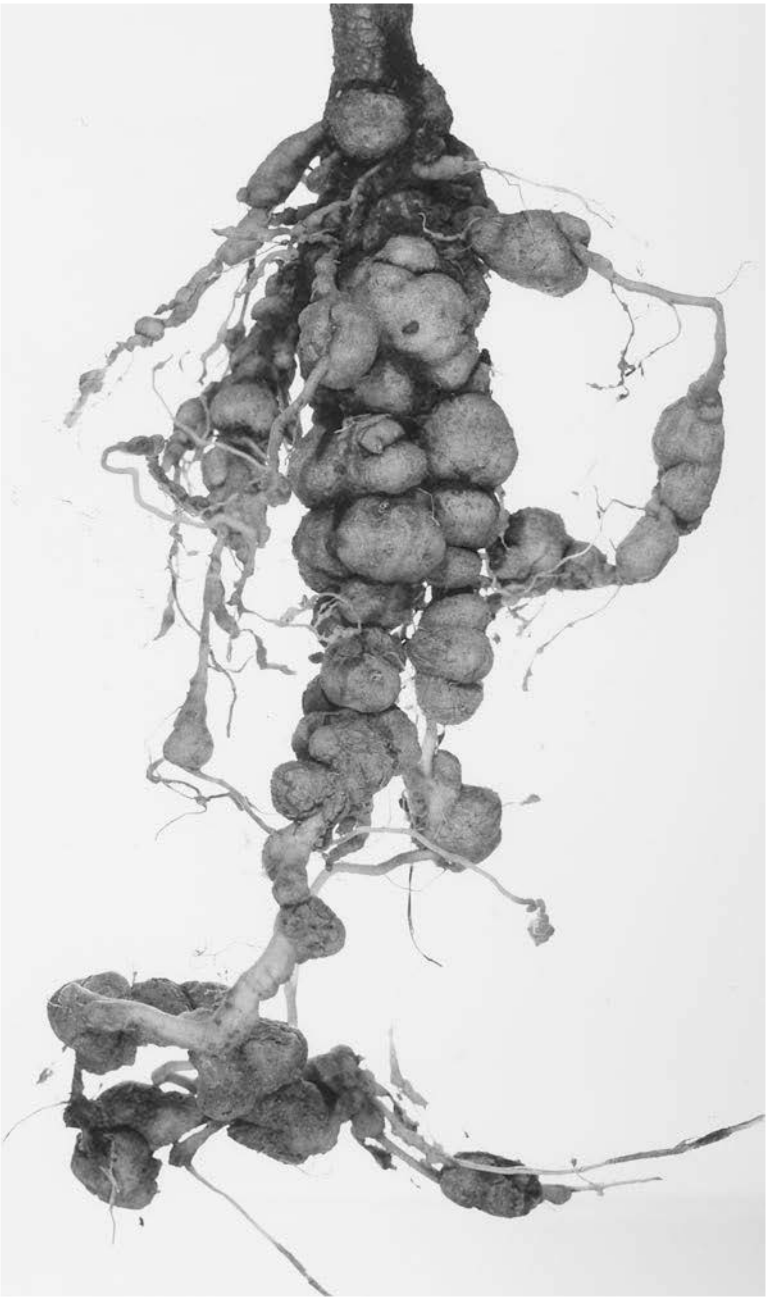


Figure 3.33 Root-Knot Nematode; pear-shaped female with egg sac; encysted young larva; and wormlike adult male

Control. Rotation of crops may be practical only for species with a narrow host range, and a few varieties of vegetables, fruits, and ornamentals have been developed resistant to particular species. Soil fumigation before planting is a common control; see ►Chap. 1 for satisfactory chemicals. These usually kill larvae free in the soil but not all of those inside root knots.

Meloidogyne arenaria. **Root-Knob Nematode**. Causes stunting and root gall on dwarf gardenia, compacta holly, and japanese boxwood. Also reported on watermelon.

Meloidogyne arenaria (formerly *Meloidogyne arenaria thamesi*). **Thames' Root-Knob Nematode**. Occurring naturally in Florida, on Chinese silk-plant (Boehmeria); found elsewhere in greenhouses. Also reported on tomato and scindapsus.

Meloidogyne arenaria thamesi (see *Meloidogyne arenaria*). **Thames' Root-Knob Nematode**.

Meloidogyne chitwoodi. **Columbia Root-Knob Nematode**. Has been associated with alfalfa, potato, tomato, sugar beet, wheat, and corn. This is significant because wheat and corn are commonly grown in rotation with potato and sugar beets to reduce *M. hapla*. Both monocotyledonous and dicotyledonous plant species are good hosts, indicating a wide host range for this nematode.

Meloidogyne graminicola. **Rice Root-Knob Nematode**. On purple nutsedge and yellow nutsedge. **Root-Knob Nematode** on clovers.

Meloidogyne hapla. **Northern Root-Knob Nematode**. Common on many outdoor crops in the North and in florist and nursery stock. Hosts include abelia, anoda, barberry, bean, blueberry, boxwood, California-laurel, cantaloupe, carrot, cherry, clematis, clovers, cocklebur, corn, cress, cucumber, dog fennel, eggplant, escarole, forsythia, geranium, germander, gladiolus, grape-hyacinth, goldenchain, jimsonweed, kale, lettuce, marigold, mock-orange, morning-glory, mulberry, myrtle, mustard, parsnip, pachysandra, pansy, peanut, peony, pepper, periwinkle, potato, privet, rose, sainfoin, sequoia, soybean, spirea, spurge, strawberry, sugar beet, tomato, velvetleaf, viburnum, wheat, and weigela.

This species is a particular pest of peanut and is probably the most important nematode on strawberries. It causes galls, reduces growth of main roots, resulting in excessive branch roots; plants are stunted and may die. Injury is more serious in sandy soils. Yields have been increased by using granular Nemagon, mixed with fertilizer, as a side-dressing or by planting in fumigated beds. Rotation with corn and some grains may be practical.

Meloidogyne incognita. **Root-Knob Nematode**. On kiwi, sequoia, society garlic, sweet potato, and jacquemontia.

Meloidogyne incognita. **Cotton Root-Knob Nematode**. A southern native associated with many plants – forage crops, bean, cabbage, cantaloupe, carrot, celery, chard, corn, cucumber, grape, lettuce, pepper, potato, radish, rhubarb, soybean, New Zealand spinach, squash, tobacco, tomato, turnip, watermelon; also on azalea, boxwood, camellia, calthea, coleus, collinsia, daylily, gardenia, hibiscus, hollyhock, iris, India love grass, nephthytis, roystonea, schefflera, and scindapsus. It was reported on iris in 1955, from New York and Texas, the first instance of rhizomatous iris credited as host to a root-knot nematode. Tips of leaves turn yellow, then brown, with whole leaf gradually dying. There are some resistant soybean varieties, and asparagus, strawberry, and peanut can be used in a rotation.

Meloidogyne incognita. **Southern Root-Knob Nematode**. Native to the South and common there, but overwintering as far north as New Jersey. This is the most important root-knot species on peach; it is also recorded on abelia, banana, bean, carrot, coleus, corn, cucumber, daylily, eggplant, gardenia, geranium, hibiscus, onion, okra, sweetpotato, pepper, tomato, watermelon, and willow. It causes stunting and chlorosis of gardenia, but does not occur on peanuts or strawberries, and these may be used in a rotation. Resistant crotalaria and oats can be used as cover crops in peach orchards, and some peach understocks are highly resistant.

Meloidogyne javanica. **Javanese Root-Knob Nematode**. Common in southern peach orchards and nurseries, widespread in Georgia on peaches such as Yunnan and Shali that are otherwise resistant to root knot. Found in northern greenhouses. May be associated with azalea, bean, beet, cabbage, calendula, carrot, carnation, corn, *Cocos plumosa*, cucurbits, eggplant, impatiens, radish, sequoia, snapdragon, soybean, tomato, and watermelon. Resistant peanut, strawberry, cotton, and pepper can be used in the rotation.

Meloidogyne ovalis. On maple.

Naccobus

Pratylenchidae. Males wormlike; females swollen in the middle, saclike, with a short, narrow tail; eggs extruded in a gelatinous matrix or held within the body; stylet with small basal knobs; endoparasites.

Naccobus aberrans. **False Root-Knob Nematode**. Important in western sugar-beet fields, also present on garden beets, cacti, carrot, crucifers, gaillardia, lettuce, and salsify. Root galls are similar to those caused by *Meloidogyne*, and may be fairly large.

Naccobus batatiformis. On cabbage, cactus, carrot, and stock

Naccobus dorsalis. Reported on heronsbill (erodium), probably on other hosts.

Nacobbodera

Heteroderidae

Nacobbodera chitwoodi. Reported on Douglas fir, and spruce.

Nothanguina

Anguinidae

Nothanguina (orrina) phyllobia. **Foliar Nematode**. On nightshade.

Paratylenchus

Tylenchulidae. Pin nematodes, related to ring nematodes but thinner, primarily ectoparasites; minute; cuticle finely annulated; female with long stylet, body ventrally curved but too short for a spiral.

Paratylenchus (*Gracilacus*) **anceps**. On California-laurel.

Paratylenchus dianthus. **Carnation Pin Nematode**. First reported on carnation in 1955 in Maryland, now well distributed through the Northeast.

Paratylenchus elachistus. On Boehmeria.

Paratylenchus (*Gracilacus*) **epacris**. **California Sessile Nematode**. Associated with a decline of black-walnut trees in California.

Paratylenchus hamatus. **Celery Pin Nematode**, **Fig Pin Nematode**. On azalea, bean, boxwood, celery, chrysanthemum, clover, corn, fig, geranium, gladiolus, turf grasses, hemlock, holly, horse-radish, iris, oak, onion, parsley, peach, pieris, pine, mountain-pink, prune, rose, soybean, strawberry, and tomato. This species is responsible for celery losses in New England, plants being stunted and chlorotic, and with decline of fig in California, symptoms being chlorosis and leaf drop and undersized fruit. On mint it has caused one-third reduction in growth. The nematodes can be starved out of celery fields by a 2-year rotation with lettuce and spinach.

Paratylenchus micoletzkyi. On marigold.

Paratylenchus macrophallus. On mint.

Paratylenchus projectus. Reported from Maryland in 1955 on pasture grasses, also found on roots of alfalfa, bean, clover, corn, spruce, and soybean. A serious decline of celery and parsley in New Jersey was attributed to this species. Preplanting fumigation has produced a striking growth response.

Paratylenchus penetrans. On snapdragon.

Pratylenchus

Pratylenchidae. Lesion nematodes, sometimes called root-lesion or meadow nematodes, widely distributed migratory endoparasites; males and females wormlike, small, 0.3 to 0.9 mm, with short stylet. Conspicuous necrotic spots are formed on roots, and eggs are deposited in root tissues or in soil. Feeding punctures afford entrance to pathogenic microorganisms.

Pratylenchus brachyurus (*P. leiocephalus*). **Godfrey's Meadow Nematode**, **Smooth-Headed Meadow Nematode**. On corn, grasses, cereals, asparagus, avocado, citrus, collinsia, dogwood, peanut, pieris, pine, pineapple, potato, soybean, strawberry, and tomato. Unsightly lesions are formed on peanut shells, and the nematode survives through curing. Preplanting soil fumigation has increased yield.

Pratylenchus coffeae (*P. musicola*). Associated with strawberry black root and decline, in Arkansas.

Pratylenchus crenatus. Associated with many kinds of nursery plants.

Pratylenchus fallax. Lesion nematode on grass.

Pratylenchus hexincisus. Described from corn roots, Maryland.

Pratylenchus minyus. On pear and grape, in California. Also, on filaree.

Pratylenchus musicola. On banana, fig, olive, and walnut.

Pratylenchus nannus. Lesions nematode; On zinnia.

Pratylenchus negelectus. Lesion nematode on potato.

Pratylenchus penetrans. **Cobb's Meadow Nematode**. Associated with decline in alfalfa, amaranth, apple, arborvitae, azalea, bean, blackberry, blueberry, boxelder, cabbage, carrot, cedar, celeriac, celery, cherry, chrysanthemum, clover, corn, cucumber, eggplant, fern, garden balsam, gayfeather, gladiolus, grass, hemlock, holly, horseradish, lettuce, lily, maple, mock-orange, onion, parsnip, peach, pear, peony, pepper, pieris, pine, mountain-pink, phlox, plum, peach, pear, potato, raspberry, rose, safflower, sequoia, soybean, spinach, spirea, strawberry, sweetpotato, tobacco, tomato, turnip, zinnia, and yarrow. This species is distributed throughout the United States. Apples have necrotic black or amber spots on white rootlets; roots may be stunted and distorted; tree vigor is reduced; leaves are small. The disease has been called "little leaf" and "rosette." The nematodes invade cortex only; secondary fungi may play a part in symptoms. Control measures include root dips and soil fumigation, hot-water treatment for strawberry stock plants, and removal of all old roots on lilies before forcing. Marigolds produce a chemical toxic to nematodes and can be used in rotations.

Pratylenchus pratensis. **DeMan's Meadow Nematode**. Important on grasses, strawberry, lily, and narcissus; reported on a great many other hosts, but there may have been some confusion with other species.

Pratylenchus safaenis. On soybean, corn, cotton, millet, rice, and sorghum.

Pratylenchus scribneri. **Scribner's Meadow Nematode**. First reported on potatoes in 1889 in Tennessee. Associated with amaryllis, hibiscus, strawberry in Florida, roses in California, and in New Jersey, clover, corn, dahlia, orchids, parsnip, peach, potato, raspberry, rose, soybean, and tomato.

Pratylenchus subpenetrans. Described from pasture grasses, Maryland.

Pratylenchus thornei. **Thorn's Meadow Nematode**. On wheat, other grains, and grasses. It has also been reported on maple and nectarine.

Pratylenchus vulnus. **Walnut Meadow Nematode**. Described in 1951 from California as an important parasite of walnut and rose on the West Coast, also present elsewhere. It may affect avocado, boxwood, almond, fig, forsythia, gayfeather, apricot, citrus, peach, plum, raspberry, loganberry, rose, sequoia, strawberry, Japanese boxwood, spiny Greek juniper, blue rug juniper, walnut, and yew. Soil fumigation has increased growth of roses by 400%.

Pratylenchus zeae. **Corn Meadow Nematode**. Associated with corn, also alfalfa, bean, chrysanthemum, cucumber, grasses, pea, phlox,.potato, soybean, tobacco, and tomato.

Pratylenchus spp. **Lesion Nematodes**. Probably as widespread as a group as root-knot nematodes and even more serious, though less readily recognized. The brown or black root condition usually comes from secondary fungi entering and rotting the roots after cells are pierced and torn by the nematodes. In boxwood and other ornamentals there is often a brush or witches' broom of new surface roots to compensate for old roots sloughed off. First symptoms are usually yellow, black, or brown lesions on fine feeder roots. Boxwood becomes sickly, stunted; foliage is dark brown to orange, sometimes drops; some branches may be killed. Tuberous begonias may be heavily infested in roots and tubers, with poor growth. Where possible, fumigate soil before planting. Help plants to recover from root injury by mulching, adequate watering, and feeding.

Radopholus

Pratylenchidae. Burrowing nematodes; endoparasites with entire life cycle inside plants, including copulation and egg deposition. Male and female wormlike, with short stylet. Female with flat lip region, two ovaries; 0.6 mm long; male with rounded lip region.

Radopholus similis. **Burrowing Nematode**, Associated with SPREADING DECLINE OF CITRUS. The most important citrus disease in Florida. This is a subtropical species, first reported in 1893 from banana roots in the Fiji Islands. Citrus decline was known for many years before the nematode connection was made in 1953. This species is also responsible for AVOCADO DECLINE and in 1963 was reported as infesting 237 plants in many families. Possible hosts include acanthus, allamanda, aluminum plant, calathea, Barbados cherry, banana, castor-bean, cocculus, hibiscus, Japanese boxwood, Japanese persimmon, ixora, jacobinia, ginger-lily, loquat, *Momordica*, pandanus, peperomia, philodendron, periwinkle, pothos, podocarpus, palms, guava, as well as corn, pepper, tomato, and other vegetables, and various trees. Asparagus, marigold, and crotalaria are among the few nonhosts. The burrowing nematode has been found in Louisiana as well as central Florida.

The nematodes enter the cortical parenchyma of young succulent roots just back of the tip and form burrows, leaving behind avenues of infection for soil fungi and bacteria. Infected trees seldom die outright, but have poor growth and cease to produce a profitable crop. The disease spreads in all directions from an infected specimen, but somewhat unevenly, the distance ranging from 25 to 200 feet in a year, averaging about 50 feet. Long-distance spread is by transplants from nurseries.

Control. Living trees, once infected, cannot be restored to vigor. Diseased trees in quarantined areas are pulled and burned, including two trees beyond those known to be infested in an orchard, and the soil is treated with D-D. Bare-rooted nursery stock can be treated with hot water, 10 minutes at

122°F. After the "pull and treat," nonhosts are grown for 2 years before citrus is replanted. There is some hope of resistant varieties.

Rotylenchulus

Hyplolaimidae. Reniform nematodes, partially endoparasitic root parasites. Female swollen, kidney-shaped; two ovaries; male wormlike, unable to feed.

Rotylenchulus reniformis. **Reniform Nematode**. First described from pineapple roots in Hawaii, now found in Florida and other warm states on turf, cotton, peanut, sweetpotato, tomato, gardenia, jacquemontia, and other ornamentals. The head of the female, with elongated neck, goes in the cortical parenchyma of the rootlet, and her kidney-shaped body projects outside. It is covered with a gelatinous material containing eggs and larvae, so that soil particles adhere.

Rotylenchus

Hoplolaimidae. Spiral nematodes, worldwide in temperate and tropical climates; mostly ectoparasitic but partially endoparasitic, somewhat migratory; body wormlike but held in shape of a spiral; long stylet; female with two ovaries; 0.5 to 1 mm long.

Rotylenchus blaberus. **Spiral Nematode** on spider-lily.
Rotylenchus buxophilus. **Boxwood Spiral Nematode**. Associated with boxwood decline in Maryland and nearby states; also found with barberry, privet, and peony. The roots have minute brown spots, and the root system is much reduced.
Rotylenchus cristiei. On grasses.
Rotylenchus robustus. Reported on azalea.
Rotylenchus uniformis. Reported on many ornamental trees and shrubs in New Jersey nurseries.

Scutellonema

Hoplolaimidae. Spiral nematodes, similar to *Rotylenchus*.

Scutellonema blaberum (*Rotylenchus blaberus*). **West African Spiral Nematode**. On banana, yam, red spider lily, and African-violet.

Scutellonema brachyurum. **Carolina Spiral Nematode**. Working at crown and roots of African-violet, destroying root cells, depositing eggs in cortical tissues. Also on amaryllis.
Scutellonema bradys. **Yam Nematode**.
Scutellonema christiei. **Christie's Spiral Nematode**. Common on lawn grasses in Florida, also reported on apple and grasses in Maryland and West Virginia.

Sphaeronema

Tylenchulidae

Sphaeronema sp. sp. **Decline** of Alaska-cedar.

Tetylenchus

Belonolaimidae. Male and female wormlike, stylet short.

Merlinius joctus. On blueberry.

Trichodorus and Paratrichodorus

Trichodoridae. Stubby-root nematodes; migratory ectoparasites with wide host ranges; thick-bodied, cylindrical; 0.5 to 1.5 mm long; smooth cuticle; tail short, bluntly rounded; long, slender stylet is a grooved tooth.

Paratrichodorus allius. Reported reducing onion yield in Oregon.
Paratrichodorus christiei. **Christie's Stubby Root Nematode**. Widespread in southern states but also present elsewhere feeding on many plants in many different plant families. These include azalea, avocado, blueberry, bean, beet, cabbage, citrus, corn, cranberry, chayote, onion, potato, squash, strawberry, tomato, and turf grasses – St. Augustine, Bermuda, and zoysia. On tomato there is general stunting and formation of short lateral roots. The stubby effect is apparently caused by a secretion and not just mechanical piercing by the stylet; there is reduced cell multiplication. The host list is too long for crop rotation to be practical, and soil fumigation is not as effective as with some other species. Asparagus and poinsettia are nonhosts, and aspara-

gus has a nematicidal effect. This nematode and some other *Trichodorus* species are vectors of tobacco rattle virus, cause of potato corky ringspot.

Trichodorus obtusus. **Cobb's Stubby Root Nematode**. On Bermuda grass.

Paratrichodorus pachydermus. **Seinhorst Stubby Root Nematode**. On turf and dahlia.

Trichodorus primitivus. On azalea.

Tylenchorhynchus

Belonolaidae. Stylet nematodes, sometimes called stunt nematodes, primarily ectoparasities, somewhat migratory, common in roots of nursery stock and cultivated plants. Male and female wormlike, 0.6 to 1.7 mm long; stylet variable in length with well developed knobs; female has rounded tail, two ovaries; male tail is pointed; cuticle coarsely annulated.

Tylenchorhynchus brevidus. On grasses.

Tylenchorhynchus capitatus. Causes stunting and chlorosis of pepper, bean, tomato, and sweetpotato.

Tylenchorhynchus claytoni. **Tesselate Stylet Nematode**. Common and widespread through southeastern and eastern states. Associated with andromeda, apple, arborvitae, azalea, bean, blueberry, boxwood, broccoli, cherry, cereals, clovers, corn, cranberry, dogwood, forsythia, grape, grasses, hemlock, holly, lettuce, lilac, maple, peach, peanut, pepper, pine, potato, raspberry, rhododendron, soybean, strawberry, sweetpotato, tomato, tuliptree, veronica, willow, and yew. Azaleas may be severely injured, with reduced root system, short twigs, leaf chlorosis and increased susceptibility to winter injury. Soil treatment with the standard fumigants and also with systemics gives adequate control. Nonhosts include peanut, pepper, cucumber, and crotalaria.

Tylenchorhynchus dubius. Reported on cereals, grasses, clovers, also azalea and carnation.

Tylenchorhynchus annulatus (formerly *Tylenchorhynchus martini*). **Sugarcane Stylet Nematode**. On sugarcane, rice, soybean, and sweetpotato.

Tylenchorhynchus martini (see *Tylenchorhynchus annulatus*). **Sugarcane Stylet Nematode**. On sugarcane, rice, soybean, and sweetpotato.

Tylenchorhynchus maximus. On turf.

Tylenchulus

Tylenchulidae. Female sedentary, with elongated anterior portion entering the root and swollen, flask-shaped posterior outside the root; well-developed stylet with large basal knobs; male remains small, cylindrical; does not feed.

Tylenchulus semipenetrans. **Citrus Nematode**. First noted in California in 1912, now widespread in citrus regions; important in California and Florida, present also in Arizona and Texas. Hosts other than citrus include olive, persimmon, grape, and lilac. Citrus trees exhibit a slow decline resulting from reduced root activity. Symptoms also include twig dieback, chlorosis and dying of foliage, wilting under moisture stress, and reduced fruit production. Control measures include resistant rootstock, and hot-water treatment of nursery stock, 25 minutes at 113°F or 10 minutes at 116°F.

Tylenchus

Tylenchidae. This genus, described in 1865, originally contained most species with stomato-stylets, but many of these have been transferred to other genera. Those left are common in soil around plants but apparently not important parasites.

Xiphinema

Longidoridae. Dagger nematodes; very common migratory ectoparasites; very long, males and females both wormlike; long, slender stylet from a bottle-shaped esophagus.

Xiphinema americanum. **American Dagger Nematode**. A native, first described in 1913 from specimens taken around roots of corn, grasses, and citrus trees. Found all over the United States associated with many kinds of plants, including ash, azalea, bean, boxwood, clover, camellia, citrus, dogwood, elm, geranium, melon, oak, palm, pea, pecan, peach, pepper, pine, poplar, rose, soybean, strawberry, sweetpotato, tomato, viburnum, vinca, and walnut. In addition to its causing decline and sometimes winterkill by its feeding on roots, this species is believed to transmit tomato ringspot, peach yellow bud mosaic, and grape yellow vein viruses and to increase the incidence of Cytospora canker on spruce. Dagger nematodes may be introduced into greenhouses with virgin soil from the woods and may destroy almost all the feeder roots of plants. There may be very high soil populations.

Xiphinema bakeri. **Dagger Nematode**. On sequoia.

Xiphinema chambersi. **Chamber's Dagger Nematode**. Causing a decline in strawberries, with stunting and sunken, reddish brown root lesions.

Xiphinema diversicaudatum. **European Dagger Nematode**. A proven pathogen of rose, strawberry, peanut, fig, tomato, soybean, garden balsam, and other plants. This species is very common in commercial rose greenhouses, reducing vigor, causing chlorosis. Galls are formed on rose roots; they are similar to root-knot galls but more elongate and nearer the tip of the root, causing it to curl. Cleaning up a greenhouse infestation means disposal of all plants in a bed, careful sterilization of soil, and replanting with clean stock.

Xiphinema index. **California Dagger Nematode**. Reported on Boston ivy, grape, fig monkshood vine, pistachio, and rose. Feeding in root tips causes a terminal swelling with angling of main roots, death of lateral roots.

Xiphinema radicicola. **Pacific Dagger Nematode**. Reported on oak, in Florida.

NONPARASITIC DISEASES

Plants in poor health from one or more environmental conditions far outnumber those afflicted with diseases caused by parasites – bacteria, fungi, and nematodes. When foliage turns yellow from lack of nitrogen, or from unavailability of iron in an alkaline soil, or from lack of oxygen in a waterlogged soil, we call it a physiological or physiogenic or nonparasitic disease. The adverse condition may be continuing, as it is with a nutrient deficiency, or it may be transitory, an ice storm, perhaps, lasting but a day but with resultant dieback continuing for the next two years. It may be chemical injury from injudicious spraying or fertilizing or from toxic substances in the atmosphere. It may be due to a toxin injected by an insect.

Trees and crops can be insured against hail, hurricanes, lightning, and other acts of God, but not the misguided zeal of gardeners. Years of working in gardens in my own state and visiting gardens in other states from coast to coast have convinced me that plants often suffer more from their owners than from pests and diseases. Azaleas die from an overdose of aluminum sulfate applied to correct acidity, when the original cause of ill health was a too-wet soil. Rhododendron die when a deep, soggy mass of maple or other "soft" leaves is kept around the trunks. Roses die when the beds are edged with a spade and soil is mounded up in the center, burying some plants too deeply and exposing roots of others. Seedlings die from an overdose of fertilizer in hot weather. Trees die from grading operations.

Spray injury is exceedingly common, with the gardener thinking the red or brown spots are fungus leaf spots and increasing the chemical dosage until all foliage is lost. Weed killers take their unexpected toll of nearby ornamentals. Either a deficiency or an excess of plant nutrients can cause a physiological disease. Greenhouse operators and commercial growers in the field must watch nutrition very carefully. The backyard farmer gets along pretty well by using a "complete" fertilizer containing nitrogen, phosphorus, and potassium in large amounts and minor elements in trace amounts. There are kits available for amateur diagnosticians who wish to check soil deficiencies and acidity, but you may prefer to send a soil sample to your state experiment station for a correct interpretation of nutrients and soil acidity. Take a slice through the soil to spade or trowel depth from several places in the garden, mix those samples together, and send a small sample of the mixture.

Acidity, Excess

Soil acidity or alkalinity is measured on a pH scale that runs from 0 to 14. When the number of acid or hydrogen ions balances the number of alkaline or hydroxyl ions, we have pH 7.0 or neutral. Above pH 7.0 the soil is alkaline and may contain free lime; below it, the soil is acid. Few crop plants will grow below pH 3.5 or above pH 9.0. If the soil becomes very acid, roots are poorly developed and may decay, growth is slow, and foliage is mottled or chlorotic. This result is due either to actual excess of hydrogen ions or to physical structure of the soil and solubility of nutrients.

Most flowering plants, fruits, and vegetables do well in a soil just slightly acid, in a pH range of 6 to 7 or 6 to 8. Plants flourishing in a very acid soil, pH 4 to 5, are few: alpines, azalea, arbutus, andromeda, bunchberry, wild calla, camellia, *Chamaecyparis* (white cedar), a few ferns, wild orchids, pitcher-plants, galax, and mountain-ash. In the pH 5 to 6 list are: arbutus-tree, azalea, bleeding-heart, birch, blueberry, bent grasses, bracken, camellia, Carolina jessamine, *Clarkia*, cranberry, cypress, *Daphne odora* (but not *D. mezerium*, which is in the 6 to 8 group), hemlock, juniper, mountain-laurel, some ferns, some orchids, some oaks, pine, rhododendron, sour gum, spruce, silver-bell tree, *Styrax*, strawberry, sweetpotato, and yew.

The small kits for home testing of soils include a booklet giving the pH preferences of a long list of plants and the amount of lime required to correct the acidity. This varies with the type of soil and the original pH. To bring a sandy soil from pH 4 to above 6 takes only 1/2 pound of hydrated lime; it takes 2 pounds of lime to effect the same change in a clay soil.

Air Pollution

Polluted air is not confined to cities. Even in the country crops suffer when sunlight plus automobile exhaust produce ozone and other gases. Air pollutants come from smelters, pulp mills, factories, power plants, incinerators, and other sources. Ozone injury is common in pine, resulting in chlorotic and needle mottling, tipburn, blight, needle flecking, and stunting; in tobacco, causing "weather fleck"; in spinach, with oily areas followed by white necrotic spots on upper leaf surface; in grape, with a dark stippling. Other sensitive plants include bean, celery, corn, tomato, carnation, orchid, radish, marigold, and petunias. Some varieties are more susceptible than others. Smog occurs from a chemical reaction of unburned hydrocarbons, as from automobiles, ozone, sunlight, and, usually, thermal inversion. Tremendous losses in California orchid houses come when smog appears when plants are in the budding stage.

Chrysanthemums may be prevented from flowering by ethylene in the atmosphere; tomatoes are also very sensitive. Injury from sulfur dioxide, a product of fuel combustion, is at a high level in the colder months. Foliage has white spots, tips, or margins. Soot particles entering houses from smokestacks cause necrotic spots.

Control. For orchids and other high-priced greenhouse crops, air can be passed through a filter of activated charcoal. Taller smokestacks reduce injury from gases and soot. Increasing the vitamin C content of plants by treating them with a substance such as potassium ascorbate may reduce injury from ozone. Installation of purification devices in automobiles and industrial plants may provide some future relief.

Alkali Injury

Some semiarid soils are nearly barren from excess of chemicals with a basic reaction. Composition varies, but three common salts are sodium chloride, sulfate of soda, and carbonate of soda; these salts become concentrated at the soil surface with a whitish incrustation. Other soils are black alkali, where the organic matter has been dissolved. Applications of gypsum or sulfur, cultivation, and mulching are correctives.

Alkalinity

Either aluminum sulfate or sulfur, or both mixed together, can be used to reduce the pH for plants doing best in a somewhat acid soil.

Aluminum Toxicity

Occasional, if aluminum is used in excess. Browning, dieback, sometimes death of azaleas and other plants may occur.

Arsenical Injury

Leaves of peaches, apricots, and other stone fruits are readily spotted or burned with lead arsenate unless lime or zinc sulfate is added as a corrective. There may be similar leaf spotting and defoliation when these tender fruits are grown in old apple land that has accumulated a residue of lead arsenate over a period of years. Even apple trees can be severely injured by arsenical sprays under some conditions.

Baldhead

In beans this is loss of the growing point, due to mechanical injury in threshing seed.

Bitter Pit

On apples this is called stippen or Baldwin spot and is characterized by small, circular, slightly sunken spots on fruit, increasing in storage, especially at warm temperatures, most frequent on varieties Jonathan, Baldwin, Spy, Rhode Island Greening. It seems to be related to fluctuation of the moisture supply in soil and increased by abundant rainfall shortly before harvest. On pear, bitter pit is sometimes associated with moisture deficiency; in olives, with overnutrition.

Black End

In pear, the whole blossom end of the fruit may turn black and dry; the disease appears when oriental pear rootstocks are used in poor soil. In walnut, black end of nuts is probably drought injury.

Black Heart

In beets, this is generally boron deficiency (see below); occasionally it is potassium or phosphorus deficiency. In apple wood it may be freezing injury; in potatoes, lack of oxygen; in celery, fluctuating soil moisture.

Black Root

Defective soil drainage and accumulation of toxins are associated with black roots, but so too are soil fungi and root nematodes.

Blasting

Blasting of influorescence and failure to produce seeds. These symptoms seem associated with extremes of soil moisture, too wet or too dry, at blossom time. Onion Blast, prevalent in the Connecticut Valley, appears within a few hours after bright sunshine follows cloudy, wet weather. Leaf tips are first white, then brown.

Blindness

Blindness of tulips and other bulbs. Failure to flower may be due to Botrytis blight or other disease, but it may come from root failure in dry soil or from heating of bulbs in storage or transit. Too early forcing may result in blindness.

Blossom-End Rot

Very common on tomatoes, also on pepper, squash, watermelon. The tissues at the blossom end of the fruit shrink, causing a dark, flattened or sunken, leathery spot, which may include nearly half the fruit (see Fig. 3.34). The disease is most common on plants that have had an excess of rainfall in the early part of the season, followed by a period of drought. There are, however, various contributing factors, the most important being a deficiency of calcium, which is needed for synthesis of rigid cell walls of the tomato. Adding calcium oxide to the soil or spraying with 1% calcium chloride has reduced the disease. For home gardens, deep soil preparation, use of a complete balanced fertilizer, and mulching to conserve moisture should help.

Bordeaux Injury

Both the copper and the lime in bordeaux mixture can be injurious to some crops. Cucurbits are stunted, and blossoming and fruit-setting are delayed in

Figure 3.34 Blossom-End Rot on Tomato

tomatoes. Red-spotting of foliage of roses and apples is followed by yellowing and defoliation. See Copper Spray Injury; Lime-Induced Chlorosis.

Boron Deficiency

A small quantity of boron is required for normal growth of most plants. For some there is not much leeway between necessary and toxic amounts; other plants require or tolerate large amounts. Deficiency symptoms vary with the crop.

Fruit trees. Internal and external cork of apples, dieback, rosette; dieback, blossom blight of pear; stunting, excessive branches, internal necrosis of peaches. Apple leaves on terminal shoots turn yellow, are convex with red veins; twigs die back from tip; dwarfed, thickened, brittle leaves are in tufts at nodes; internodes are abnormally shortened. Fruit has dry corky lesions throughout the flesh or diffuse brown lesions and bitter taste. McIntosh, Baldwin, Rome, Northwestern Greening, and Jonathan exhibit external cork with severe russeting of surface. Control by applying borax, 1 ounce per each inch of diameter of tree trunk, in a 1-foot band outside the drip of the branches. Apply only once in 3 years, and reduce the amount by half for peaches and other stone fruits and for very sandy soils.

Beets, turnips, other root crops. Black Heart, Brown Heart. Roots have dark spots; plants are gradually stunted and dwarfed; leaves are small, variegated, twisted. The interior of the beet or turnip has a dark brown to nearly black water-soaked area, sometimes with a hollow center. The amount of borax that can be added without injury depends on type of soil and moisture content.
Celery. Cracked Stem. Leaves have a brownish mottling; stems are brittle, cracked with brown stripes.
Lettuce. There is malformation of young leaves, death of growing point.
Ornamentals. Terminal flower bud dies; top leaves are thick and brittle. Application of boron in fritted form has prevented splitting in carnations, and has increased flower production in greenhouse roses.

Boron Toxicity

Retardation or prevention of germination, death or stunting of plants, bleaching or yellowing of tops, disappearance of color along midrib and veins, all are indications of excess boron. Beans are extremely sensitive to boron, with injury from as little as 4 pounds borax broadcast per acre. If borax has been used for root crops, boron-tolerant cabbage should follow before beans in the rotation.

Brown Bark Spot

Brown Bark Spot of fruit trees. Perhaps this is arsenical injury from residue in the soil.

Brown Heart

Brown Heart of turnip, cabbage, cauliflower. ►Boron Deficiency.

Bud Drop

In sweet pea very young flower buds turn yellow and drop off when there is a deficiency of phosphorus and potassium during periods of low light intensity. Water sparingly at such periods; avoid excess of nitrogen. Gardenias often drop their buds when taken from greenhouses to dry homes, but there is also bud drop in greenhouses with high soil moisture, high temperature, and lack of sunlight in winter.

Calcium Chloride Injury

Trees may be damaged when this dust-laying chemical is washed off country roads or driveways down to roots.

Calcium Deficiency

All plants require calcium, which is built into walls of cells, neutralizes harmful by-products, and maintains a balance with magnesium and potassium. Calcium is leached out of the soil as calcium carbonate and should be replaced by adding ground limestone, or dolomite (calcium magnesium carbonate), or gypsum (calcium sulfate), which does not increase the pH of the soil.

In fruits, calcium deficiency shows first in the roots, which are short and stubby with a profuse growth behind the tips that have died back. Basal immature peach leaves sometimes have reddish discolorations, and twigs may die back. Corn and legumes require large amounts of calcium, which may become unavailable under conditions of high soil acidity.

Catface

Fruit deformity, due to insects or growth disturbances.

Chlorine Injury

A tank of chlorine gas for the swimming pool carelessly opened too close to trees and shrubs causes foliage browning and sometimes death. Leaf margins are sometimes killed by chlorine gas from manufacturing processes.

Chlorosis

Yellowing or loss of normal green color may be due to deficiency of nitrogen, magnesium, or manganese. Occasionally boron deficiency or toxicity, insufficient oxygen to the roots in a waterlogged soil, or alkali injury may cause chlorosis but in the majority of cases, and particularly with broad-leaved evergreens, it occurs because iron is unavailable in an alkaline soil. ► Iron Deficiency.

Chlorosis

Hydroponically grown basil with interveinal chlorosis associated with CO_2 enrichment.

Copper Deficiency

Exanthema or dieback of fruits – apple, apricot, citrus, olive, pear, prune; failure of vegetables on muck soils. Copper deficiency in fruits is widespread in Florida and occurs frequently in California. Leaves are unusually large and dark green, or very small and quickly shed, on twigs that die back, with a reddish brown gummy discharge. Citrus fruits are bumpy and drop, or have insipid flavor and dry pulp. Application of copper sulfate to the soil corrects the deficiency, but often spraying trees once or twice in the spring with bordeaux mixture provides sufficient copper indirectly. Spraying almonds with a copper chelate has prevented shriveling of kernels. Muck or peat soils in New York, formerly unproductive, now grow normal crops of onions and lettuce with the addition of copper sulfate. On copper-deficient Florida soils, many truck crops fail to grow or are stunted, bleached, and chlorotic.

Copper Spray Injury

Some fixed copper sprays are less injurious than bordeaux mixture, but all coppers may be harmful to some plants under some conditions. Foliage spots are small, numerous, reddish, sometimes brown. In peach leaves the centers of the spots may fall out, leaving shot holes. Rosaceous plants follow spotting with yellowing and dropping of leaves. Even mild coppers may be injurious if the temperature is below 55°F, or the weather continues rainy or cloudy. Treated leaves are often harsher than normal and more subject to frost injury. Dwarfing and stunting are important symptoms on many crops, especially cucurbits. Tomato flowering is injured or delayed; apple and tomato fruits are russeted. Tree roots are injured by overflow from pools treated with copper for algae.

Cork

Boron deficiency, in apple.

Cracked Stem

Boron deficiency, in rhubarb, celery.

DDT Injury

Foliage of some plants – cucurbits particularly, roses occasionally – turns yellow or orange, often with stunting. Certain camellia varieties have been injured when shrubs are under trees sprayed with DDT. Continued spraying with DDT builds up a residue in the soil which may eventually have a toxic effect on the root system, the effect varying with the type of soil and plant.

Dieback

This is due to deficiency or excess of moisture, nutrients; winter injury; also cankers, nematodes, borers.

Drought

The effects of a prolonged dry period may be evident in trees and shrubs for two or three years thereafter.

End Spot

End Spot of avocado. Unequal maturity in both ends of the fruit seems to be a factor in withering, spotting, and cracking at lower end. Pick promptly, instead of leaving on trees.

Exanthema

Copper deficiency, in fruits.

Frost Injury

This injury is caused by low temperature after plants have started growth in spring or before they are dormant in fall (see Winter Injury for freezing

Figure 3.35 Frost Injury on Holly

during the dormant period). Yellow color of some leaves in early spring is due to temperatures unfavorable for chlorophyll formation. Some leaves, including those of rose, are reddened or crinkled with frost (Fig. 3.35). Blossom buds of fruit trees are critically injured by frost late in spring. In the South, where plants come out of dormancy early, orchard heaters, smudge fires, power fans, and airplanes flying low to stir up the air are all used to help save the crop. Many ornamentals are injured when a long, warm autumn ends in a sudden very cold snap, or warm weather in February or March is followed by heavy frosts. Cracks in tree trunks come from such temperature fluctuations.

Gas Toxicity

Illuminating gas escaping from aging gas mains causes slow decline or sudden death, depending on the plant. Tomatoes are extremely sensitive and indicate the slightest trace of gas by leaves and stems bending sharply downward. Plane trees develop “rosy canker” – long, narrow cankers near the trunk base with inner bark watermelon-pink and swollen. With large amounts of gas escaping, foliage wilts and browns suddenly, followed by death of twigs and branches; with slow leaks, the symptoms appear gradually over a year or two. After the leak is repaired, it is sometimes possible to save trees by digging a trench to aerate the roots, applying large quantities of water, burning out severely injured roots, then replacing soil and feeding to stimulate new growth.

Natural gas is, apparently, not as injurious.

Girdling Roots

Unfavorable conditions sometimes deflect roots from their normal course, and one or two may grow so closely appressed to a tree as to almost strangle it. If one side of a tree shows lighter green leaves with tendency to early defoliation, dig down on that side to see if a root is choking the trunk under the soil surface. The root should be severed and removed, then all cut surfaces painted.

Grading Injuries

Many shrubs die when they are planted much deeper than the level at which they were grown in the nursery. Similarly, many trees die when they are covered over with fill from house excavations. Roots require oxygen for survival, and a sudden excess of soil cuts off most of the supply. A tree expert should be on hand to give advice before any digging starts. Afterward is too late. And if grading means filling in soil around trees, a little well around the trunk is not enough. There must be radial and circular trenches laid with tile, and then crushed stone and gravel, before the top soil goes in place. Consult *Tree Maintenance* by P. P. Pirone for clear descriptions and diagrams for protecting trees from contractors.

Graft Incompatibility

Lilacs are sometimes blighted from incompatibility of the lilac scion on privet stock. Walnut girdle is due to incompatibility of scions on black walnut roots.

Gummosis

Formation of gum on bark of fruit trees is commonly formed in cases of bacterial canker, brown rot, crown rot, and root rots from soil fungi and in connection with the peach tree borer, but other cases of gummosis seem connected with adverse sites and soil moisture conditions irrespective of parasitic organisms.

Heart Rot

Boron deficiency, in root crops.

Heat Injury

There are many ways in which excessive high temperatures can injure plants, ranging from death to retarded growth or failure to mature flowers and fruit. Sunstroke, outright killing of plants, is a limiting factor in flower and vegetable production in summer in the South. Seedlings, especially tree seedlings and beans, may have heat cankers with stem tissues killed at the soil line. See also Sunscald, Leaf Scorch, Tipburn.

Hollow Heart

This is sometimes due to excessive soil moisture.

Hopperburn

Marginal chlorosis, burning and curling of leaves of potatoes and dahlias is due to leafhoppers.

Internal Browning or Cork

Internal Browning or Cork of apple. Boron deficiency.

Iron Deficiency

Iron is seldom, or never, actually deficient in the soil, but it is often in such an insoluble form in neutral or alkaline soils that plants cannot absorb it, or it may be precipitated as insoluble iron phosphate where excessive amounts of phosphates are added to the soil. Chlorosis is an indication of the lack of iron, for it is necessary for the formation of chlorophyll, the green pigment (see Fig. 3.36). In acid soils iron is usually available; in alkaline soils leaves turn yellowish green, often remaining green along the veins but yellowing in

Figure 3.36 Iron Deficiency in Chrysanthemum

interveinal areas. Terminal growth of twigs is small, and the shrub or tree is generally stunted.

To obtain a quick response it is possible to spray leaves with a solution of ferrous sulfate. More lasting is a soil treatment of a 50-50 mixture of ferrous sulfate and sulfur.

Rather recent is the use of chelated iron, sold as Sequestrene and under other trade names. In this form the iron cannot be combined with soil elements and remains available to the plant even under alkaline conditions. The solution, prepared according to directions on the package, is poured on the soil around the unthrifty bush, and often the green color returns in a matter of days. Iron chelates are now extensively used for citrus and for ornamentals.

Leaf Scorch

Leaf Scorch, of maple, horse-chestnut, beech, walnut, and other trees. Scattered areas in the leaf, between the veins or along the margins, turn light or dark brown, with all the leaves on a branch affected more or less uniformly. The canopy of the tree looks dry and scorched; leaves may dry and fall, with new leaves formed in summer. Lack of fruiting bodies distinguishes scorch from a fungus leaf blotch. It appears during periods of high temperature and drying winds and often after a rainy period has produced succulent growth.

Leaf scorch of Easter lilies has been a problem for years but can be prevented by keeping the pH of soil near 7.0 with lime, adequate nitrogen, but low phosphorus. It may have some connection with root rots.

Leaf scorch of iris has puzzled amateur growers in the past few years; it is more serious in the Southwest but has appeared in gardens elsewhere. Leaves turn bright reddish brown at the tips in spring before flowering, and in a few days the whole fan is scorched and withered, and the roots have rotted with a reddish discoloration (see Fig. 3.37). Many theories, including nutrition and nematodes, have been advanced, but there is no general agreement as to cause.

Lightning Injury

Trees may be completely shattered or a narrow strip of bark and a shallow layer of wood torn down the trunk. Tall trees or those growing in the open

Figure 3.37 Scorch in Iris

are most likely to be struck. Valuable trees can be protected with lightning conductors, installed by a competent tree expert.

Lime-Induced Chlorosis

Plants are sickly, with yellow foliage, in calcareous soils or near cement foundations. ►Iron Deficiency.

Little Leaf

Little Leaf, on almond, apricot, avocado and other fruits. ►Zinc Deficiency.

Magnesium Deficiency

Large areas in the Atlantic and Gulf Coast truck crop regions are low in magnesium because of natural lack of magnesium rock, extensive leaching from heavy rainfall, removal of large quantities in crops, and use of fertilizers lacking this element. In tomatoes, veins remain dark green while rest of leaf is yellow or chlorotic. Cabbages have lower leaves puckered, chlorotic, mottled, turning white at the margin and in center. In strawberries, leaves are thin, bright green, then with necrotic blotches. On fruit trees, fawn-colored patches are formed on mature, large leaves, with affected leaves dropping progressively toward the tip. In flowering plants there are a greatly reduced rate of growth, yellowing between veins of lower leaves, sometimes dead areas between veins, sometimes puckering.

Control by using dolomitic limestone, or with fertilizers containing magnesium, or with Epsom salts (magnesium sulfate) around azaleas and other shrubs in home gardens.

Manganese Deficiency

Top leaves become yellow between veins, but even smallest veins retain green color, giving a netted appearance. Lower the pH below 7 and add manganese sulfate to the soil.

Marginal Browning

Potassium deficiency or hopperburn.

Mercury Toxicity

Roses are extremely sensitive to mercury vapor and have been gravely injured when paints containing mercury were used to paint sash bars in greenhouses. Covering the paint with a paste of dry lime sulfur mixed with lime, flour, and water reduced the amount of toxic vapor.

Molybdenum Toxicity

Cause of whiptail in broccoli and cabbage, chlorosis of citrus in Florida, of grapes in Michigan. Citrus leaves have large interveinal yellow spots with gum on undersurface and may fall. Injecting the trunk with sodium molybdenate has corrected the condition quickly. On grapes chlorosis of terminal leaves was attributed to molybdenum deficiency correlated with nitrogen toxicity and was corrected by adding 0.01 ppm molybdic acid to nutrient solutions.

Mottle Leaf

Zinc deficiency.

Nitrogen Deficiency

Symptoms are paleness or uniform yellowing of leaves, and stems, firing or burning of lower leaves, sometimes red pigments along veins, stunted growth, reduced yield with small fruit. Immediate results can be obtained by side-dressing with a quickly available nitrogenous fertilizer, but long-range planning includes use of legumes in the rotation, green-manure crops, and balanced fertilizers. Urea is recommended for turf, one application providing a slow release through the season.

Nitrogen Excess

Too much nitrogen leads to overdevelopment of vegetative growth at the expense of flowers and fruit; to bud drop of roses, sweet peas, and tomatoes; and, in high concentrations, to stunting, chlorosis, and death. Excessive nitrogen decreases resistance to winter injury and to such diseases as fire blight, powdery mildew, and apple scab.

Oedema

Small, wartlike, sometimes corky, excrescences are formed on underside of leaves of many plants – cabbage, tomatoes, geraniums, begonia, camellias, etc. When roots take up more water than is given off by leaves, the pressure built up may cause enlarged mesophyll cells to push outward through the epidermis. This condition is rare outdoors but is found in greenhouses and sometimes on house plants where they have been overwatered. Copper sprays sometimes produce similar intumescences. Camellias frequently have corky swellings on bottom surface of leaves, often due to water relations, sometimes to a spot anthracnose fungus.

Oxygen Deficiency, Asphyxiation

Overwatered house plants and crops in poorly drained low situations often show the same symptoms as those caused by lack of water, for the roots cannot respire properly and cannot take up enough water. Improve drainage; lighten soil with compost and sand; avoid too much artificial watering.

Phosphorus Deficiency

Young leaves are dark green; mature leaves are bronzed; old leaves are mottled light and dark green. In some plants there is yellowing around leaf margins. Stems and leafstalks develop reddish or purplish pigments; plants are stunted, with short internodes; growth is slow, with delayed maturity. Most complete commercial fertilizers have adequate phosphorus, but it can be added separately in the form of superphosphate. In preparing rose beds apply a liberal amount at the second spade depth as well as in the upper soil.

Potassium Deficiency

Marginal browning, bronzing, or scorching appears first on lower leaves and advances up the plant, which is stunted. Leaves are often crinkled, curl inward, develop necrotic areas; the whole plant may look rusty. The lack of potassium can be made up with a complete fertilizer containing 5 to 10% potash. Wood ashes also help to supply potassium.

Ring Spot

Yellow rings on African-violet foliage come from breaking down of the chloroplasts when the leaf temperature is suddenly lowered, as in watering with water considerably colder than room temperature.

Rosette

Zinc deficiency in pecan and walnut, boron deficiency in apple.

"Rust"

This term is used by amateur gardeners for any rust discolorations – for a leaf blight of phlox of unknown origin (probably a water relation), a spot necrosis of gladiolus, red-spider injury, and many other troubles that have nothing to do with true fungus rusts.

Salt Injury

Trees and shrubs along the seacoast are injured by ocean spray, and after hurricanes and high winds traces of injury can be found 35 to 40 miles inland. Conifers are usually affected most; they appear damaged by fire, with needles bright yellow, or orange-red. Eastern white pine is very susceptible; Austrian and Japanese black pines, blue spruce, and live oak are highly resistant. Roses have often survived submersion in salt water during hurricanes.

Roadside trees, and e specially maples, may be injured by salt used on highways during the winter. Either sodium chloride or calcium chloride may be harmful.

Scald

Scald, of apple. Asphyxiation injury to fruit in storage from accumulation of harmful gases; most important when immature fruit is stored without adequate ventilation at too high temperature and humidity. Wrapping fruit in oiled paper or packing with shredded oiled paper, and storage near 32°F, with a high concentration of carbon dioxide at the start, control scald.

Scorch

► Leaf Scorch.

Shot Berry

Shot Berry, of grape. Defective pollination.

Smog Injury

Unsaturated hydrocarbons and ozone in the atmosphere are the cause, with many kinds of plants injured in the Los Angeles area. Tan lesions appear on fern leaves in 24 hours with necrosis in 24 more (Fig. 3.38). Many ornamentals and vegetables are injured, with annual loss $3 million. Spraying carnations in greenhouses with Vitamin C prevents sleepiness from smog. Some greenhouses have installed activated-carbon filters for polluted air.

Figure 3.38 Ozone Injury on Tobacco

Smoke Injury

The most important agent in smoke injury is sulfur dioxide, a colorless gas with a suffocating odor released from smelters and many industrial processes. Acute smoke injury shows in rapid discoloration of foliage, defoliation, sometimes death. Conifer needles turn wine red, in whole or part, then brown. Leaves of deciduous trees have yellow to dark brown dead areas between veins, with tissue next to larger veins remaining green. Chronic injury results in unhealthy, stunted trees, but less apparent discoloration and defoliation. Roses, grapes, and legumes are seriously injured. Gladiolus leaves appear burned from the tips down.

Control of injurious smoke must be at the source – by filters, tall smokestacks, neutralizing the acid gases, or using them in the manufacture of sulfur and sulfuric acid.

Soot Injury

City trees and shrubs acquire an accumulation of soot, the solid residue of smoke, which screens out the sunlight. Evergreens can be sprayed with a soapy solution of Calgon (sodium hexametaphosphate), followed by syringing with clear water.

Stigmonose

Dimpling of fruit by insect punctures.

Sulfur Injury

Sulfur sprays and dusts are likely to burn foliage in hot weather, when temperature is much over 85°F. There is often a browning of tip or margin of leaves. Lime sulfur is injurious to some plants in any weather, russeting peach foliage, causing apple drop, etc. When roses or other plants are continuously dusted with sulfur over a period of years, the soil may become too acid and require lime as a corrective.

Sunscald

Trees with smooth bark are subject to sunscald when trunks or branches are suddenly exposed to the sun, as when the next tree is removed. Young trees are subject to sunscald the first year or two after planting and should have trunks wrapped in burlap or sprayed with a protective wax to prevent the cambium under the thin bark from drying out.

Boxwood foliage is subject to sunscald in spring after winter covering is removed, particularly if this is done on a sunny day with drying winds.

Sunscald is common on green tomatoes when fruits are exposed to sun in hot dry weather (Fig. 3.39). This happens when foliage is lost through disease or excessive irrigation, or when too much is removed in training tomatoes to a single stem. A yellow or white patch appears on the side of the tomato nearest the sun, often developing into a blister, then into a large, flattened spot with a papery white surface darkened by the growth of secondary fungi and internal decay.

Figure 3.39 Tomato Sunscald

Sunstroke

Outright killing in excessive heat.

Tipburn

Potassium deficiency may produce a tipburn, but more often this is a reaction to heat, common in potatoes and particularly in lettuce, which shows marginal browning of leaves and small brown or black spots in tissues near larger veins. A regular supply of moisture and avoidance of excessive fertilization in warm weather reduce tipburn, but more reliance should be placed on growing varieties resistant to summer heat.

Topple

Topple, of gladiolus. Toppling over is apparently due to calcium deficiency; reduced by a spray of 2% calcium nitrate.

Variegation

Chlorophyll deficiency, genetic factors, and virus diseases can produce variegated plants.

Water Deficiency

Practically all of the injury laid to excessive heat or cold is basically due to lack of water. Winter winds and summer sun evaporate it from cells faster than it can be replaced from roots, so that the cells collapse and die.

Weed-Killer Injury

There has always been some unintentional injury to neighboring plants in the use of weed killers of the kill-all variety on driveways; but since we have had 2,4-D as a selective weed killer for lawns, the damage to innocent bystanders has been enormous, not only from spray drift and volatile material in the atmosphere but from using for other spraying purposes equipment that

Figure 3.40 Weed-Killer Injury; Tomato and Oak

has applied 2,4–D. It is impossible adequately to clean out such a sprayer; mark it with red paint and keep it for weeds only. Symptoms of injury are curling, twisting, and other distortions; there is often a fern-leaf effect instead of normal-size foliage (Fig. 3.40). I have seen roses seriously malformed when a factory several hundred feet away mixed up some 2,4-D. I have seen tall oaks with all leaves unrecognizable after powdered 2,4-D was applied to the lawn. I have seen chrysanthemum in a greenhouse utterly deformed when 2,4-D was used on a lawn outside. Fortunately, unless the dose is too heavy, the plants gradually grow back to normal.

Winter Injury

Most winter browning of evergreens is due to rapid evaporation of water in sudden warm or windy spells. Copious watering late in the fall, a mulch, and windbreaks are helpful for broad leaf evergreens, as is spraying them with a waxy material, Wilt-Pruf, which prevents evaporation.

Sudden icestorms cause obvious breaking in trees; in boxwood and similar shrubs they result in bark sloughing off and gradual dieback for months, even years afterwards. I have seen symptoms on azaleas long after the ice was forgotten.

Yellows

This term is used for some deficiency disease but also for various virus diseases and Fusarium wilts.

Zinc Deficiency

Little Leaf of almond, apricot, apples, grape, peach, plum. Foliage is small, narrow, more or less crinkled, chlorotic at tips of new growth, with short internodes producing rosettes of leaves. Defoliation progresses from base to top of twigs. The method of supplying zinc depends somewhat on the fruit. Spray apples, peaches, plums, pears during dormant period with zinc sulfate. Swab grape vines immediately after winter pruning.

Mottle Leaf of citrus. Leaves are small, pointed, with a sharply contrasting pattern of green along midrib and main laterals and light green or yellow between veins.

Rosette of pecans and walnuts. Narrow, crinkled leaflets with dead or perforated areas have a rosette appearance; trees often bear no nuts. Pecan growers in southeastern states broadcast zinc sulfate on soil under each tree in winter. Variety Money-maker is resistant to zinc deficiency.

Vegetable crops – corn, beans, tomato, soybean – have been protected by amending the soil with 23 pounds zinc sulfate per acre.

POWDERY MILDEWS

Mildew is a disease in which the pathogen is seen as a growth on the surface of plants. The same word is used for the fungus causing the disease. Mildews are Ascomycetes. Black mildews are parasites in the order Meliolales with a dark mycelium to give a sooty effect. They are common in the South or on tropical plants in greenhouses (►Black Mildew). Powdery mildews are plant parasites in the order Erysiphales. They have white mycelium, in a delicate weft or thick felt, made up of a criss-cross tangle of hyphae. Colorless spores borne in chains on upright conidophores give the white powdery effect (see Fig. 3.41). False or downy mildews are oomycetes, and the conspicuous growth is not vegetative mycelium but fruiting structures and conidia protruding through stomata or epidermis to give a white frosty appearance in moist weather (►Downy Mildews).

True powdery mildews – and in speaking of them we usually eliminate the word "powdery" – are widely distributed but sometimes more abundant in semiarid regions than in areas of high rainfall, where other diseases flourish. Unlike those of most other fungi, powdery mildew spores do not require free water for germination. Some species require high humidity, but it is usually provided at the leaf surface when cold nights change to warm days or when plants are grown in crowded, low, or shady locations without sufficient air circulation. Spores of other species can germinate with very low humidity.

When a mildew spore lands on a leaf and puts out its germ tube, it does not make its nearest way inside the leaf but produces a tangle of septate threads, hyphae, on the surface. Special sucking organs, haustoria, penetrate the epidermal cells, occasionally the subepidermal cells, in search of food. The penetrating tube is slender, but, once inside the cells, the haustorium becomes a round or pear-shaped enlargement or a branched affair, with greatly increased absorbing surface.

Condiophores, growing at right angles from the mycelium, produce one-celled conidia in rows or chains of somewhat barrel-shaped hyaline cells, which become oval as they are dislodged from the top of the chain and dis-

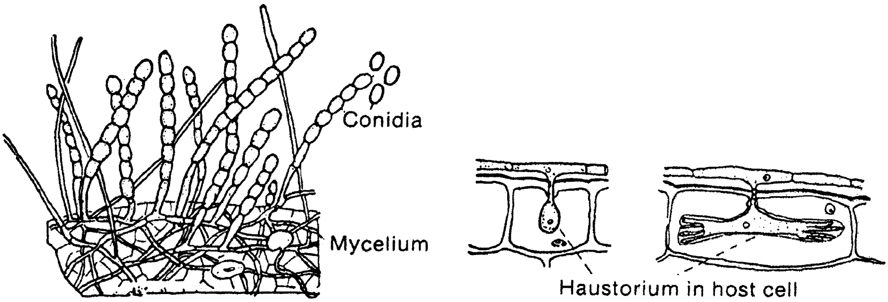


Figure 3.41 Powdery Mildew: mycelium and conidia formed on surface of a leaf and two types of the haustoria in host cells

seminated by wind. Mildews known only in this anamorph state are called by the form genus name *Oidium*. It requires the sexual fruiting bodies, perithecia, to place mildews in their proper genera.

Perithecia are round with a dark membranous wall, technically cleistothecia because they have no beak or ostiole, and rupture irregularly to free the asci. They are held in place in the mycelium by appendages. The form of these appendages and the number of asci in the perithecium are the chief characters differentiating the six genera important in this country (see Fig. 3.42). *Sphaerotheca* and *Erysiphe* both have simple appendages; but the former has only one ascus, the latter several. *Podosphaera* has appendage tips dichotomously branched and one ascus; *Microsphaera* has the same type of appendage but several asci. *Phyllactinia* has lancelike appendages swollen at the base; those of *Uncinula* are coiled at the tip. Both have more than one ascus.

Powdery mildews are obligate parasites, having no saprophytic growth periods in dead plant parts, although the perithecia carry the fungus through the winter on either living or dead tissue. Mycelium sometimes winters in buds. Symptoms of mildew are dwarfing and stunting, often with a slight reddening and curling of leaves before the white mycelium is noticeable. There may be deformation of flower buds. Such symptoms are due to the withdrawal of plant foods by the fungus and to excessive respiration.

Sulfur dust and lime sulfur sprays have long been considered specific remedies for powdery mildews; some copper sprays are effective. Many of the newer organics are ineffective. However, inorganics, in a formulated form, i. e. potassium biocarboante are very effective and safe.

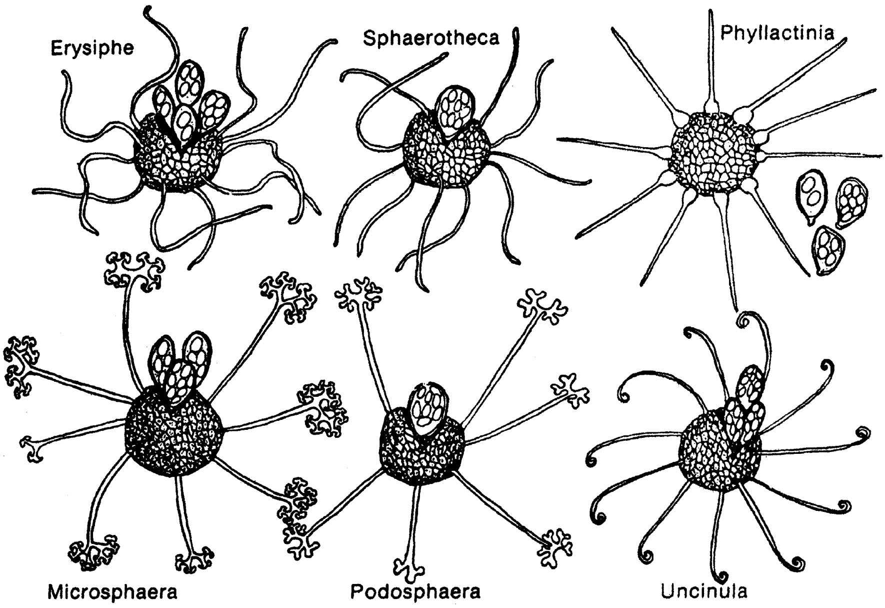


Figure 3.42 Powdery Mildews. Perithecia (cleistothecia) of the six genera: *Erysiphe*, simple appendages and several asci; *Sphaerotheca*, same with one ascus; *Mycrosphaera*, dichotomously branched appendages and several asci; *Podosphaera*, same with one ascus; *Phyllactinia*, appendages bulbous at base; *Uncinula*, appendages coiled at tip

Erysiphe

Cleistothecia globose, or globose-depressed, sometimes concave; asci several, two- to eight-spored; appendages floccose (cottony), simple or irregularly branched; sometimes obsolete, usually similar to mycelium and interwoven with it; mycelium brown in rare cases.

Blumeria graminis (see *Erysiphe graminis*). **Powdery Mildew** of cereals and grasses, economically important on bromegrass, wheat, oats, barley, and rye; aesthetically important on lawn grasses, wheatgrass, fescue, and bluegrass.

Brasiliomyces trina (formerly *Erysiphe trina*). **Oak Powdery Mildew**, on tanbark oak and coast live oak, in California, causing witches' brooms (but ►*Sphaerotheca lanestris* for the common live-oak mildew). Perithecia are small, yellow-brown, with appendages lacking or rudimentary; asci have two, rarely three, spores.

Erysiphe aggregata. **Alder Powdery Mildew**. Perithecia large, asci with eight spores, rarely six or seven.

Golovinomyces cichoracearum (formerly *Erysiphe cichoracearum*). **Powdery Mildew** of cucurbits and many ornamentals, mostly composites, perhaps best known to gardeners as the **Phlox Mildew**. Asci are two-spored, perithecia rather small, haustoria not lobed. There are nearly 300 hosts including: cucumber, squash, pumpkin, gourds, cantaloupe, watermelon, lettuce, endive, Jerusalem artichoke, pepper, potato, salsify, Echinacea, Eucalyptus, *Achillea, Anchusa, Artemisia*, aster, begonia, *Boltonia*, calendula, campanula, chrysanthemum, clematis, coreopsis, cosmos, dahlia delphinium *Eupatorium*, gaillardia golden-glow, goldenrod, *Helenium*, hollyhock, *Inula*, mallow *Mertensia* phlox, rudbeckia, *Salpiglossis*, salvia (sage), sunflower, stokesia and zinnia.

There are various strains of the fungus, the form on cucurbits not affecting ornamentals, the strain of phlox (see Fig. 3.43) is reportedly limited to that host, the strain on zinnia with a wide range of host plants. The lettuce strain, perhaps a mutation of the form on wild lettuce, was not reported on cultivated lettuce before 1951 and is important only in California and Arizona.

Powdery mildew was reported on cucurbits in North America in 1890, but did not gain much prominence until 1926, when it suddenly reduced the melon crop in the Imperial Valley of California by 5000 carloads. By 1939 mildew-resistant Cantaloupe 45 had been developed to meet the situation, but in another decade the fungus had produced a different strain to which Cantaloupe 45 was susceptible. Plant breeders can never rest on their laurels because fungi that are obligate parasites seldom stay long outwitted. Other varieties, Cantaloupes 5, 6, and 7, were bred resistant to both strains of the fungus.

Powdery mildew is the principal disease of cucumbers in greenhouse culture, with tiny white superficial spots on leaves and stems enlarging and becoming powdery. Young watermelon fruits in greenhouses have small pimples or warts under the area covered by mildew mycelium.

Phlox mildew is only too familiar to gardeners. The white coating often appears on variety Miss Lingard in June, but on other varieties (in New Jersey) more prominently in July and August. The mycelium is present on both leaf surfaces and forms a thick felt on stems. In late summer black perithecia are formed in great abundance. Powdery mildew on zinnias and chrysanthemums usually starts so late in the season that it is more conspicuous than harmful.

Figure 3.43 *Erysiphe cichoracearum* on Phlox

Control. Sulfur dust gives excellent control but is phytotoxic to some melons and other cucurbits. Sulfur-tolerant cantaloupes have been produced. The variety Homegarden is supposedly resistant to mildew and other pests. Keep phlox and other ornamentals well spaced, and dust with sulfur at the first sign of white growth. Because the perithecia winter on old stems and leaves, plants should be cut at ground level in autumn and burned.

Erysiphe cruciferarum. **Powdery Mildew** on cabbage and turnip.

Erysiphe graminis (syn. **Blumeria graminis**). **Powdery Mildew** of cereals and grasses, economically important on bromegrass, wheat, oats, barley, and rye; aesthetically important on lawn grasses, wheatgrass, fescue, and bluegrass. The foliage is yellow or chlorotic with a white weft or mealy coating on upperside of leaf, which later turns yellow and is often studded with tiny brown perithecia. Seed from infected plants is small and shriveled. Apply sulfur dust or wettable sulfur sprays.

Erysiphe heraclei. **Powdery Mildew** on carrot, parsley, chervil (culinary herb), and celery.

Erysiphe orontii. **Powdery Mildew** on mint.

Erysiphe panax. **Powdery Mildew** on ginseng.

Erysiphe polygoni. **Powdery Mildew** of legumes, and many other vegetables and ornamentals, about 200 species in 90 plant genera. Appendages are long or short, interwoven with the mycelium, but the perithecia are not immersed in it. Asci have three to six spores. Peas exhibit a white powdery coating over leaves and pods, with the latter often discolored. Leaves are sometimes yellowish and deformed. The disease may be severe on peas in arid sections of western states, particularly on late homegarden varieties.

On beans, the mildew is grayish. It is prevalent in California in cloudy weather or in autumn when humidity is increased, but it is more important in the Southeast. Other vegetables infected by this species include lima bean, soybean, cabbage, turnip, radish, horse-radish, and carrot. Spores germinate at quite low humidity.

The legume mildew is widespread on lupine, occasional on sweet pea. Other ornamental hosts include acacia, anemone, arrowleaf clover, candytuft, calendula, California poppy, iceland poppy, China aster, clematis, columbine, dahlia, delphinium, *Erigeron*, gardenia, geranium, hydrangea, honeysuckle, locust, matrimony-vine, peony, sugar beet, and tulip-tree. Teleomorph state found on sugar beet in CO, MT, NB, WA, and WY.

Control. Choose resistant vegetable varieties or dust with sulfur. Spray or dust ornamentals with Karathane or sulfur.

Erysiphe taurica (► *Leveillula taurica*). On leaves of mesquite.

Erysiphe trina (see *Brasiliomyces trina*). **Oak Powdery Mildew**, on tanbark oak and coast live oak, in California, causing witches' brooms (but ► *Sphaerotheca lanestris* for the common live-oak mildew).

Erysiphe sp. **Powdery Mildew** on tomato.

Leveillula

Cleistothecia globose, or globose-depressed, sometimes concave; asci two- to eight spored; appendages floccose (cottony), simple or irregularly branched; usually similar to mycelium and interwoven with it.

Leveillula taurica (formerly *Erysiphe taurica*). On leaves of mesquite. Commonly causes powdery mildew on tomatoes in Eastern Mediterranean region and reported on fresh market tomato in California and Utah; also on cucumber, hibiscus, onion, guar, wild tobacco, cotton and desert bird of paradise.

Microsphaera

Cleistothecia globose to globose-depressed; appendages branched dichotomously at apex, often ornate; asci several, with two to eight spores.

Microsphaera penicillata. Named for the alder (*Alnus*), on which it is widespread, but best known to gardeners as the **Lilac Mildew**. It also infects many other trees, shrubs, and vines, including azalea, beech, bittersweet, birch, catalpa, dogwood, elder, elm, euonymus, forestiera, hazelnut, magnolia, mountain-holly, plane, New Jersey tea, privet, trumpetvine, and viburnum. According to some taxonomists the proper name of this species is *Microsphaera penicillata*, but *M. alni* is more familiar and still widely used. Mildew is prevalent on lilac in late summer and fall, sometimes in dry seasons, almost completely covering foliage with a thick white coating; but, because it comes so late in the season, it is not very injurious. It is also common on deciduous azaleas in late summer, forming a very thin grayish white coating with numerous prominent dark perithecia. This species is more prevalent than the legume mildew on sweet peas, but it is chiefly a greenhouse problem in spring, when temperatures and humidity are less uniform. The foliage may be malformed, dropping prematurely or drying out and shriveling.

Among tree hosts oaks are probably most susceptible, but it would seldom pay to attempt control measures except in nursery rows. On pecans the white coating starts forming on leaves and nuts in July with occasional defoliation, shuck splitting, and shriveled kernels. Most commercial pecan varieties are mildew-resistant.

Blueberry Mildew is caused by a special strain of lilac mildew, reported as *Microsphaera vaccinii*, and *M. penicillata* var. *vaccinii*. Varieties Pioneer, Cabot, and Wareham are said to be particularly susceptible; Concord, Jersey, and Rubel are intermediate; and Stanley, Rancocas, Harding, and Katherine, highly resistant. On some blueberries the mycelium is conspicuous on upper leaf surfaces, on others barely visible on underside. Midsummer defoliation weakens the bushes. Cranberries, farkleberries, trailing arbutus and lyonia are possible hosts to this strain.

Control. Bordeaux mixture is recommended for pecans – two applications, June and July. Dust blueberries with sulfur. Use sulfur on lilacs and other ornamentals.

Microsphaera diffusa. General on snowberry, widespread on wolfberry, coralberry, occasional on black locust, lima bean, kidney bean and soybean. Appendages are two to four times the diameter of the perithecia, with ultimate branches long, forming a narrow fork.

Microsphaera euphorbiae. On lima bean, euphorbia, roselle.

Microsphaera grossulariae. **European Powdery Mildew**, occasional on currant, gooseberry. There is a light weft of mycelium mainly on upper surface of leaves. For the more important American mildew ►*Sphaerotheca mors-uvae*.

Microsphaera penicillata. **Powdery Mildew** on *Leucothoë axillaris*.

Microsphaera pulchra. **Powdery Mildew** on flowering dogwood.

Oidium

This term is used for mildews known solely from the conidial stage. In some cases the type of conidial fructitication may suggest correct genera, but until perithecia are found, *Oidium* is preferred.

Oidium araliacearum. **Powdery Mildew** on English Ivy.

Oidium begoniae. **Begonia Mildew**, especially important on tuberous begonias on the West Coast, though it may also occur on fibrous-rooted begonias.

Oidium dianthi. **Carnation Powdery Mildew**.

Oidium euonymus japonici. **Euonymus Mildew**, general throughout the South and on the Pacific Coast on *Euonymus japonicus*. The mycelium forms a thick felt on the leaf surface, causing some yellowing and defoliation (see Fig. 3.44). I have seen this disease rampant in foggy coast towns like Beau-

Figure 3.44 Powdery Mildew on Euonymus; prevalent in the South

fort, South Carolina, or Mobile, Alabama, and equally severe in semiarid El Paso, Texas. The washing effect of a water spray applied with pressure, either by adjusting the hose nozzle or putting the thumb over a portion of the orifice, is a deterrent to this mildew. Sulfur dust can be used, probably Karathane.

Oidium obductum. On oriental plane.

Oidium pyrinum. On crabapple.

Oidium tingitaninum. **Citrus Mildew**, common in Java, Ceylon, India, but in this country causing only limited injury to tangerine trees in California. White patches are formed on upper surface of leaves, the tissue underneath first a darker, watery green, then losing color, turning yellowish.

Oidium sp. On greenhouse snapdragons, a white powdery growth on both leaf surfaces, sometimes on young stems. Control with Karathane or sulfur.

Oidium sp. On avocado, occasionally in Florida, in nurseries or on young trees in shaded locations. Tips of shoots are killed back; dark green spots appear on upper leaf surfaces with white mycelium on the underside. The mildew can be controlled with lime sulfur. On alfalfa in Wisconsin.

Oidium sp. On shrub banana in LA.

Oidium sp. On black medic in CA.
Oidium sp. On *Melilotus alba* in FL.
Oidium sp. On poinsettia.
Oidium sp. On tomato.
Oidium sp. On Torena.

Phyllactinia

Perithecia are large; appendages are lancelike with a bulbous base. Mycelium does not send haustoria into epidermal cells of host but forms special branches that pass through stomata into intercellular spaces; each of these intercellular branches or hyphae sends a single haustorium into the adjacent cell.

Phyllactinia angulata. **Powdery Mildew** on elm.
Phyllactinia corylea (syn. *P angulata*). **Powdery Mildew** of trees, named for the hazelnut or filbert but prevalent on many other trees and shrubs, such as amelanchier, ash, barberry, beach, birch, boxwood, catalpa, chinaberry, crabapple, currant, blackberry, raspberry, gooseberry, crape-myrtle, dogwood, buttonbush, chestnut, elm, elder, fringe-tree, hawthorn, hickory, hornbeam, holly, linden, oak, plane trees, quince, rose, sassafras, tulip-tree, walnut and willow. Mildew is seldom serious enough on shade trees to warrant control measures, but in the nursery dusting with sulfur may be advisable. It is common on filberts in Oregon, but comes so late in the season it does not affect yield.

Podosphaera

Perithecia globose; one ascus, with eight spores; appendages dark brown or colorless, dichotomously branched at tip; rarely an extra set of basal appendages present.

Podosphaera leucotricha. **Powdery Mildew** of apple, also crabapple, pear, quince, photinia. First noted in Iowa on seedling apples in 1871, this mildew became more important in orchards when organic fungicides, ineffective for mildew, were substituted for sulfur and copper in the apple-scab schedule. Twigs, foliage, blossoms and fruits may be disfigured, stunted, deformed or killed. Gray to white felty patches are formed on leaves, usually on underside. Leaves are crinkled, curled, sometimes folded longitudinally and covered with masses of powdery spores. They soon turn brittle and die, resulting in decreased yield. The same powdery growth starts on 1-year twigs, but in midsummer it is transformed into a brown, felty covering, in which minute, dark perithecia are embedded in dense aggregations. Infected twigs are stunted or killed. The fungus winters as dormant mycelium on twigs or in buds. Such buds produce shriveled blossoms and no fruit. Fruit produced on infected twigs is stunted or russeted. Jonathan variety is especially susceptible.

Podosphaera clandestina (*P. clandestina* var. *tridactyla*). **Powdery Mildew** of cherry, occasional on plum, peach, apricot, apple, pear, quince, hawthorn, serviceberry, spirea. Budded sour cherry is most severely attacked, but the disease is seldom serious except on nursery stock. Young leaves and twigs are covered with a white mycelium and powdery spores. Leaves are curled upward; terminal leaves are smaller; twig growth is stunted. Sulfur sprays or dusts will control.

Podosphaera pannosa (formerly *Sphaerotheca pannosa* var. *rosae*). **Rose Mildew**, general on rose; distinct from peach mildew but apparently not confined to rose, since apricots growing near roses have been infected. More than one strain may be involved. Rose mildew is found wherever roses grow. Always a problem with greenhouse roses, it was enhanced when aerosol treatments for red spiders and other pests were substituted for old-fashioned syringing. Mildew increased in garden roses when ferbam and other new organics replaced the old sulfur and copper in the blackspot sprays. Rose mildew is omnipresent along the Pacific Coast and is serious in the semiarid Southwest. In the East, it appears on small-flowered ramblers such as Dorothy Perkins and Crimson Rambler in May, and may be quite serious on hybrid teas and some floribundas in late summer, with the advent of cool nights.

The first symptom may be a slight curling of leaves, with the mycelial growth such a light and evanescent weft as to be almost unnoticed. Later the white coating is conspicuous from the chains of conidia produced lavishly over the surface. The coating may cover buds, resulting in no bloom or distorted flowers. Leaves often have a reddish or purplish cast under the white mycelium and sometimes turn black. They may be slightly blistered. On canes, the growth is heavier and more felty, especially near thorns. Toward the end of the season perithecia may be found on canes, but they are not common, and I have not seen them on leaves except on a Rugosa rose at Ithaca, New York. Mildew is prevalent on soft succulent shoots, fostered by an excess of nitrogen.

Control. Sulfur dusts have been standard treatment for garden roses for many years; to be effective dusting must be started at the first sign of mildew, before the mycelium gets too thick. Sulfur may be injurious to roses in very hot weather. Choice of variety of rose is important. Shiny-leaved climbers like Dr. Van Fleet seldom have mildew, and the shrub polyantha, The Fairy, is very resistant. Many red roses, hybrid teas and fluoribundas, are especially susceptible, but the orange-red floribunda Spartan remains free from it (in my own experience). Garden planning avoids a lot of mildew trouble. Keep the plants well spaced, in beds away from buildings, and not surrounded by tall hedges or walls.

Podosphaera tridactyla. Recently reported on almond in California and the most common mildew on apricot, causing large nonnecrotic lesions on leaves.

Sphaerotheca

Appendages simple, flexuous, resembling hyphae; only 1 ascus in a perithecium.

Cystotheca lanestris (formerly *Sphaerotheca lanestris*). **Powdery Mildew** of coast live oak on *Quercus agrifolia* in California, reported also on white, southern red, bur and post oaks. The disease is most destructive in the narrow coastal plain. The most conspicuous symptom is a powdery white, stunted growth developing from certain terminal or lateral buds. The shoots are swollen, fleshy, with much shortened internodes. Foliage on such shoots is often reduced to pale yellow, bractlike leaves, which turn brown, dry, and shrivel; these shoots resembles witches' brooms. On leaves developing from normal buds and shoots, the fungus forms a dense layer on both surfaces, more abundant on the lower side. This species is sometimes called the brown mildew because the grayish-white mycelium changes to tan and then brown with age. Perithecia are formed in the brown felt, abundantly in some years, rarely in others. In southern California the fungus may winter in the conidial state, with widespread leaf and shoot infections coming from wind-borne spores.

Control is not easy. Spraying with lime sulfur in March and October is fairly effective but may be phytotoxic at high temperatures and low humidity. Wettable sulfur has not been consistently effective. Removal of witches' brooms by pruning back to normal lateral branches is effective only if the tree is slightly susceptible and conditions for reinfection are unfavorable. Heavy pruning stimulates new growth and increases the amount of mildew. The Holm or holly oak is apparently resistant to mildew and well adapted to the coastal region.

Sphaerotheca castagnei (see *Sphaerotheca fuligena*). On buffaloberry, spirea.

Sphaerotheca fuliginea (formerly *Sphaerotheca castagnei*). On buffaloberry, spirea.

Sphaerotheca fuliginea. **Powdery Mildew** of summer squash and cucurbits.

Sphaerotheca fusca. Powdery mildew; on ground-cherry.

Sphaerotheca lanestris (see *Cystotheca lanestris*). **Powdery Mildew** of coast live oak on *Quercus agrifolia* in California, reported also on white, southern red, bur and post oaks.

Sphaerotheca macularis (*S. humuli*). **Hop Mildew**, also on fruits, blackberry, dewberry, gooseberry, raspberry, strawberry, rose (probably rarely in this country), and other ornamentals, including *Agastache*, betony, buffaloberry, delphinium, *Epilobium, Erigeron*, gaillardia, geranium, geum, gilia, hawksbeard, hawkweed, *Hydrophyllum*, kalanchoë, matricaria, meadowsweet, ninebark, *Polemonium*, phlox, sumac, spirea, tamarisk and *Vernonia*.

This mildew may be important on Latham variety of raspberry, appearing on new canes when they are 2 to 3 feet high. The tip leaves are dwarfed, mottled, and distorted, almost as if they had mosaic. The undersurface of leaves is water-soaked or has the familiar white coating. There is no specific control except to space plants for free air circulation.

The powdery mildew sometimes serious on strawberries in northeastern and Pacific Coast States is probably a special strain. The edges of affected leaves curl upward, exposing the lower surface, where the powdery frosty growth is evident. Fruit, stems, and berries may be affected, with fruit often failing to color. Resistant varieties include Sparkle, Puget Beauty, Siletz and India.

Sphaerotheca mors-uvae. **American Gooseberry Mildew**, also on currant; sometimes the limiting factor in gooseberry production. Fruits dry up with a brown, felty covering. Leaves and canes are stunted with the usual white coating. Perithecia are formed on canes, and ascospores are discharged in early May as fruit is set. Conidia for secondary infection are produced within 10 days. Spray with lime sulfur immediately after bloom.

Sphaerotheca pannosa var. **persicae**. **Peach Mildew**, general on peach, also on almond, apricot, nectarine, matrimony-vine, and *Photinia*. The mycelium is pannose (ragged) or in dense patches, persistent, usually satiny, shining white, or sometimes grayish or brown. Immature fruits are highly susceptible. They have brown blotches and are scabby and malformed. The fungus winters in shoots. Nonglandular varieties Peak and Paloro are more affected than glandular Walton, Johnson, Halford, and Stuart, at least in California. Sulfur in the spray schedule for brown rot should control mildew without additional treatments. Karathane is effective but very slightly phytotoxic. Lime sulfur is recommended.

Sphaerotheca pannosa var. **rosae** (►*Podosphaera pannosa*). **Rose Mildew**, general on rose; distinct from peach mildew but apparently not confined to rose, since apricots growing near roses have been infected.

Sphaerotheca phytoptophila. Associated with gall mites causing witches' brooms on hackberry. The mycelium is evanescent; perithecia are formed inside loose scales of enlarged buds.

Sphaerotheca sp. On *Tolmiea*, pick-a-back plant, in greenhouse.

Uncinula

Perithecia globose; appendages uncinate, slightly coiled at tips; several asci, with two to eight spores.

Pleochaeta prosopidis (formerly *Uncinula prosopidis*).

Uncinula circinata. On maples, Virginia creeper, western soapberry.

Uncinula clintonii. General on American linden.

Uncinula flexuosa (see *Uncinuliella flexuosa*). **Horse-Chestnut Powdery Mildew**, on *Aesculus* spp., including red, yellow and Ohio buckeye, widespread in central and eastern states.

Uncinula macrospora. General on American and winged elms.

Uncinula necator. **Grape Powdery Mildew**, general on grapes, also on *Ampelopsis*; common in late summer on eastern grapes but not serious; a major problem in California. Leaves, canes and young fruits are covered with white patches; growth is often distorted. Late in the season the white mycelium disappears and the spots appear brown or black; berries are russeted or scurfy, failing to mature.

Control. Keep California grapes covered with a light coating of sulfur dust. Apply when new shoots are 6 to 8 inches long; when they are 12 to 16 inches, 14 days later; when shoots are 2 to 3 feet; when fruit is half.grown; when fruit begins to ripen. If some of the applications are omitted, and mildew gets a head start, wettable sulfur is used as an eradicant spray. Karathane is also effective. Copper sprays are often used in the East, if any are necessary. Bicarbonate sprays are excellent as protectant and eradicant.

Uncinula parvula; **U. polychaeta**. Widespread on hackberry and southern hackberry.

Uncinula prosopidis (see *Pleochaeta prosopidis*). On mesquite.

Uncinula salicis (see *Uncinula adunca*). **Willow Powdery Mildew**, also on pussy willow and poplar, sometimes causing defoliation but not often serious.

Uncinuliella australiana. (not *Erysiphe lagerstroemiae* as reported earlier in U.S.). **Crape-Myrtle Powdery Mildew** on crape-myrtle only, from Maryland to Florida and Texas, the most serious disease of this shrub. The perithecia have been found only in Florida, but presumably it is the same species throughout the host range. The disease appears on young shoots in early spring, later infecting leaves and different parts of the influorescence. Affected parts are covered heavily with a white mealy to dusty growth; young leaves are stunted, often less than one-third normal size but abnormally thickened. Internodes are short, flower stems stunted; buds often fail to develop flowers. Infected portions often have a reddish discoloration under the white coating. Diseased leaves and buds drop in a week or two, but stems may sprout again and sometimes produce normal growth in hot weather.

The fungus winters as mycelium in dormant buds and in spring covers such buds with a dense white coating of conidia, the source of primary infection, which starts as small, circular white patches on young leaves. Spores produced in abundance on these patches account for rapid spread of the disease until midsummer heat.

Control. Spray with lime sulfur when buds burst in spring and repeat 2 weeks later. If the initial infection is not checked, spray wettable sulfur or dust with sulfur.

Uncinuliella flexuosa (formerly *Uncinula flexuosa*). **Horse-Chestnut Powdery Mildew**, on *Aesculus* spp., including red, yellow and Ohio buckeye, widespread in central and eastern states. This mildew gives a very thin coating on the leaf surface, supposedly mostly on the underside although I have seen it on the upper. Perithecia are numerous, small, barely discernible with the naked eye. Control is usually unnecessary except in nurseries. A copper spray used for blotch will also control mildew.

Uncinula adunca (formerly *Uncinula salicis*). **Willow Powdery Mildew**, also on pussy willow and poplar, sometimes causing defoliation but not often serious. The growth is in diffused or circumscribed patches on both leaf surfaces.

ROTS

A rot is a decay, a decomposition or disintegration of plant tissue. It may be a hard dry decay or a soft and squashy one. It may affect root or rhizome, stem, tree trunk, blossom or fruit. Some rots also affect leaves, but diseases that are primarily of foliage are more often designated leaf spots or blights. Rots caused by bacteria are discussed under Bacterial Diseases.

There are a great many wood rots of trees, recognized by the sporophores or conks of the various species of *Fomes, Polyporus*, and other shelving or bracket fungi. By the time these signs appear, it is usually too late to do anything about the disease. The tree-rot fungi enter through unprotected wounds – either pruning cuts or breaks due to wind and icestorms. For proper pruning methods and treatment of wounds, see U.S. Department of Agriculture Farmers' Bulletin 1896, *Care of Damaged Shade Trees, Tree Maintenance* by P. P. Pirone or *Tree Experts Manual* by Richard R. Fenska. The fact that tree wound dressings are now available in convenient aerosol bombs should make it easier for home gardeners to protect pruning cuts from wood-rotting fungi.

Physalospora (Acanthorhynchus)

Ascomycetes, Amphisphaeriales

Perithecia separate, innate, beaked; spores one-celled, dark.

Acanthorhynchus vaccinii (see *Physalospora vaccini*). **Cranberry Blotch Rot**, a common fruit rot thriving in warmer sections, more important in New Jersey than in Massachusetts.

Physalospora vaccini (formerly *Acanthorhynchus vaccinii*). **Cranberry Blotch Rot**, a common fruit rot thriving in warmer sections, more important in New Jersey than in Massachusetts. The rot starts as a small, light-colored spot on the berry, spreading to destroy the whole fruit, with dark blotches on the skin. The fungus may invade leaves, but it seldom fruits on them until they have fallen. Cranberry bogs in New Jersey may need three or four sprays of Bordeaux mixtures starting at midbloom, but in Massachusetts two are sufficient.

Acremonium

Acremonium sp. **Root Rot** on melon and watermelon.

Alternaria

► Blights.

Alternaria alternata. **Fruit Rot** on tomato and black pit disease on potato tubers (stored).

Alternaria citri. **Alternaria Rot** of citrus fruits, navel-end rot, black rot, widespread, prevalent in warm dry sections, but not too serious. In oranges the rot is most common in the Washington Navel variety – a firm, dry, black rot at the navel end, often in only one segment, with fruit coloring prematurely, appearing sound on the outside. In lemons the disease is a soft, dark internal rot of old or weak fruit in storage. Firm dark brown spots are formed on the rind. Grapefruit sometimes has a dark internal storage rot, not readily discernible externally.

Control. Chemical treatment after picking is not very satisfactory. Produce sound fruit in the orchard; avoid holding too long on the tree; avoid holding weak or old fruit too long in storage; store at low temperatures.

Alternaria mali. **Fruit Rot**, widespread storage rot of apple, sometimes quince. Also a weak parasite enlarging injured spots on foliage. Try captan at 6- to 14-day intervals.

Alternaria radicina (Syn. *Stemphylium radicinum*). **Black Rot** of carrots, a soft storage rot of roots held over winter. Rot may start at the crown or from some wound on the side of the root. Initial infection may be in field or in storage house; a black mycelial weft with large, brown muriform spores develops over the rotted tissue. There is no control except to choose firm, healthy roots for storage and to store at low temperatures.

Alternaria solani. **Collar Rot** of tomato, also fruit rot and early blight, general on tomato with the collar rot stage most frequent in the South. ► Blights.

Alternaria zinniae. **Stem Rot** on *Ageratum*.

Alternaria sp. **Flower Rot** of Vanda orchids, causing infection in transit along with *Botrytis*.
Alternaria sp. On Schefflera in Florida.
Alternaria sp. **Calyx-End Rot** on apple.

Amphobotrys

► Cankers and Dieback.

Amphobotrys ricini. **Stem Rot** and **Wilt** of poinsettia.

Aphanomyces

Phycomycetes, Saprolegniales.

Thallus composed of cylindricaI branching hyphae without definite constrictions; sporangium cylindrical, threadlike, swarm spores arranged in a single row and encysting at the mouth; saprophytic or parasitic, living in the soil and causing root rots or damping-off.

Aphanomyces cladogamus. Causing rootlet necrosis of tomato, pepper, spinach, and a severe root rot of pansy.
Aphaomyces cochlioides. A seedling disease of sugar and table beets, part of the complex called black root; causing tip rot, a wilting of tops. Crop rotation and proper fertilization are helpful.
Aphanomyces euteiches. **Pea Root Rot**, also on bean, sweet pea and perennial pea. The fungus is also a weak parasite in roots of many non-legumes. First described in 1925, the fungus probably existed earlier in various root disease complexes and was responsible for giving up land formerly devoted to canning peas. Considered the most important of the pea root rots, found in every district, it is particularly destructive in eastern and central states.
The fungus is parasitic on subterranean parts, causing root and stem rot in peas of all ages, symptoms and crop yield varying with the time of infection. If the root system is invaded when only three or four nodes are formed, the plant may wilt and die suddenly; later invasion results in dwarfing and drying out of foliage from the ground upward. When seedlings are pulled out of the ground, the roots do not break off but come out as a fibrous string or vascular cylinder freed from cortex. The fungus invades only the cortex or roots and

base of stem, causing softening and rapid decay of tissue. Large numbers of thick-walled oospores are formed in the cortex; these may remain viable in the soil more than one season.

It is a novel root pathogen on alfalfa in Canada.

Control. A well-drained soil with low moisture content decreases rot. When soil moisture is at 45% of saturation, there is no disease; at 75% there may be more than 70% infection. Nitrogenous fertilizers are helpful.

Aphanomyces raphani. **Radish Black Root** and **Damping-Off**, widespread; more important on long-rooted icicle varieties. Also on Abyssinian mustard, cabbage, Chinese cabbage, Chinese kale, honesty, mustard green, rape, rocuet salad, sea-kale, Spanish mustard, wild radish and *Brassica robertiana*. Small, steel-gray to black areas appear around point of emergence of secondary roots. Enlarging roots are constricted and turn black. Rotation is essential for control. Choose globe rather than long varieties.

Armillaria

Basidiomycetes, Agaricales.

One of the mushrooms, cap-shaped on a stalk with an annulus or ring but no volva (cup) at the base; gills attached to the stem; spores white (see Fig. 3.45).

Armillaria mellea. **Mushroom Root Rot** of trees and shrubs, also known as Armillaria root rot or toadstool disease, first described in America in 1887, known in Europe a hundred years earlier. The fungus is called honey mushroom, honey agaric, oak fungus and shoestring fungus. Although the honey-colored toadstools are often seen in the East around rotting tree stumps and may occasionally cause death to weak ornamental trees, the chief damage is west of the Rocky Mountains, especially in California, where most fruit and nut crops and ornamental trees and shrubs are menaced.

The decay is of the roots and root crown. Sheets of tough, fan-shaped mycelium are found between bark and wood, the latter changing to light tan, becoming soft and watery in texture. Clumps of toadstools are often found at the base of dead or dying trees, especially in autumn, but do not always appear in dry seasons. They are honey-colored or light tan, with a stalk 4 to 6 inches or more high and a cap 2 to 4 inches across, often dotted with brown scales. Basidiospores formed along the gills are wind-borne. They can establish themselves in old stumps and dead trees but cannot infect healthy trees. The latter are infected in the ground by means of black or brown cordlike

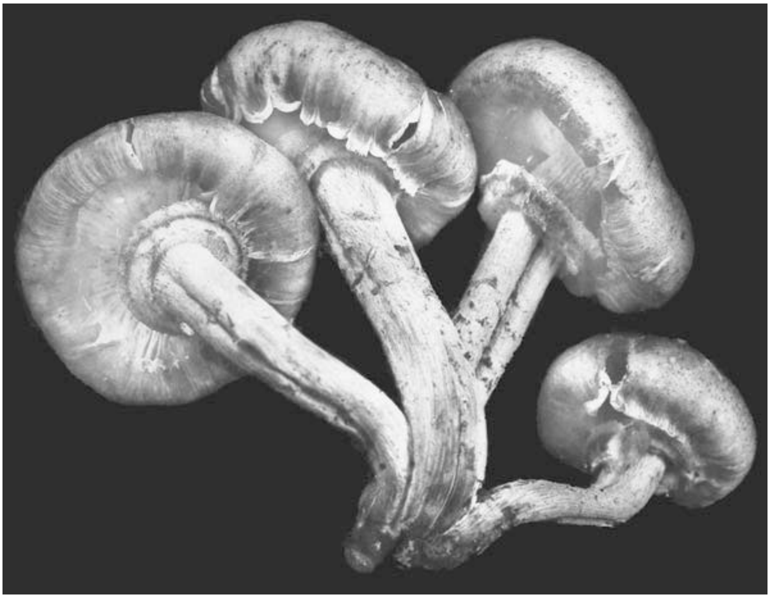


Figure 3.45 Mushroom Root-Rot Fungus, *Armillaria mellea*

rhizomorphs, the “shoestrings,” which grow out from infected roots a short distance through the soil. On meeting and penetrating a healthy root, the fungus progresses along the cambium layer, working up to and girdling the root crown. Leaves are dwarfed, turn yellow or fall prematurely; on small trees all foliage may die simultaneously. On conifers, particularly pines, there is an abnormal flow of resin from the root collar.

Trees subnormal in vigor and suffering from drought are most injured. Orchards of citrus and other fruits on lands recently cleared of oaks are liable to enormous damage unless resistant rootstocks are used. The rot is found less often on dry hillsides than in valleys near streambeds, where flood waters deposit soil and infected debris around root crowns, or in places kept too wet by artificial watering. Ornamental trees and shrubs are often injured when extra soil is added in grading and terracing, and are then kept too wet by watering the lawn frequently.

The list of susceptible plants is far too long to be given in entirety. A representative selection includes almond, apple, apricot, avocado, cherry, citrus, currant, grape, incense cedar, peach, pear, plum and raspberry, hickory, filbert and walnut, California pepper-tree; oaks, pines, spruce and sycamore;

azalea, rhododendron, boxwood and rose; (root, crown, and stem rot on) African daisy and (stem rot on) sunflower;and sometimes other herbaceous plants such as begonia, carnation, dahlia, narcissus, peony, rhubarb, and strawberry.

Control. Use resistant plants where possible. Of fruits, only French pear, Northern California black walnut, fig and persimmon are sufficiently resistant to grow safely on infested soil. Some plants can be grafted onto resistant rootstock such as Myrobalan 29. The University of California has prepared a list of resistant or moderately resistant ornamental shrubs. Some on the list are *Acacia decurrens* var. *mollis, A. verticillata, Buxus semipervirens, Ilex aquifolium, Lonicera nitida, Prunus ilicifolia* (hollyleaf cherry), *P. lyoni* (Catalina cherry), *Pyracantha coccinea* and var. *lalandii* but not *P. angustifolia*, which is susceptible.

Moderately resistant shrubs include *Abelia grandiflora*, Darwin, Japanese, and Mrs. Wilson barberry, Mexican orange (*Choisya*), *Elaeagnus argentea, Euonymus japonica*, Japanese privet, *Myrtus communis, Pittosporum tobira* and *Spiraea prunifolia*.

Mechanical measures are often helpful. Excavate and expose the root crown; remove diseased portions of bark and affected small roots. Paint wounds with a pruning wound compound. Leave the treated roots exposed until cool weather in autumn. Trenching or digging a ditch around a plot will restrict the disease temporarily, but roots will grow through the ditch in time.

Carbon disulfide is still recommended as a soil disinfectant, applied in staggered rows, in holes 18 inches apart each way, which should be immediately closed by tamping. Hand applicators are available for injecting the disulfide 6 to 7 inches deep. This treatment is for land where valuable trees have been removed; one cannot go closer to a healthy tree than the edge of the branch spread. After treatment, the land should remain fallow for at least 60 days, and then be ploughed before planting.

Ascochyta

► Blights.

Ascochyta pinodes. **Foot Rot** of peas. Of the three species that make up the Ascochyta blight complex, this one produces most definitely a foot rot, with infection at the root crown or base of stem.

Aspergillus

Deuteromycetes, Coelomycetes

Conidiophores have a round head at the top, with radially arranged bottle-shaped sterigmata that bear conidia in chains; spores are one-celled, globose to ellipsoid, hyaline. Bread molds are in this genus. When, rarely, a sexual fruiting body (cleistothecium) is formed, the species is placed in the order Eurotiales.

Aspergillus alliaceus. **Cladode Rot**, **Stem and Branch Rot** on *Cereus* and *Opuntia* cacti. This is a high temperature species. Spores are yellow in mass.

Aspergillus fumigatus. **Wound Rot** (storage) on beet.

Aspergillus niger. **Calyx-End Rot** of dates, **Fig Smut**, **Bunch Mold** of grapes, **Pomegranate Rot**, **Black Mold** of peach. **Crown Rot** of peanut; also market and storage rot of shallot, onion, apple and potatoes. The fungus is a weakly parasitic black mold invading ripe tissue through wounds. In dates, the interior of the fruit is filled with a black dusty mass of spores, spread to a large extent by the dried-fruit beetle. Practice orchard sanitation; keep decaying fruits cleaned up so insects cannot carry spores.

Aspergillus niger var. **floridanus**. Wound parasite on *Dracaena*. Lower stem black, rotted, with dark brown spore masses.

Aspergillus spp. Green and yellow molds causing secondary rots of many fruits and some vegetables in storage.

Lasiodiplodia (Botryodiplodia)

► Blights.

Botryodiplodia theobormoae (see *Lasiodiplodia theobromae*). **Root Rot** on apple

Lasiodiplodia theobromae (formerly *Botryodiplodia theobormoae*). **Root Rot** on apple.

Botryosphaeria

► Blights.

Botryosphaeria dothidea. **Fruit Rot** of peach and grape.

Botryosphaeria obtusa. **Fruit Rot** of peach, **Black Root Rot** of apple.
Botryosphaeria rhodina. **Fruit Rot** of peach.
Botryosphaeria ribis (Anamorph, *Dothiorella gregaria*). **Dothiorella Rot** of avocado and citrus, **Black Fruit Rot** of apple and pear, **Nut Rot** of tung oil. On avocado this is a soft rapidly spreading surface rot, starting from small spots when fruit begins to soften. The fruit may be covered with decay spots by the time it is usable. The fungus winters in dead twigs, in tip-burned leaves, and enters the avocado while it is still on the tree. Two sprays, mid-September and early October, using bordeaux mixture, have given fairly good control. Remove dead wood from trees, to reduce source of inoculum, and pick fruit early.
On lemons and other citrus fruits the rot starts as a discoloration around the button, becoming a brown, leathery but pliable decay. When fruit is entirely involved it becomes olivaceous black. On tung, brown lesions appear on green fruit, which drops prematurely. See further under Cankers.

Botryotinia

► Blights.

Botryotinia convoluta. **Botrytis Crown Rot** of iris, **Gray Mold Rot** on rhizomatous iris, first recorded in Canada in 1928 and apothecia later produced in culture. The chief diagnostic character is the presence of many shining black sclerotia, much convoluted and agglomerated into large clusters on rotting rhizomes. These are often found in spring on plants that started into the winter apparently healthy, for the fungus is active in cool, wet weather. Conidiophores are brown, formed in fascicles, and bear dense clusters of light brown ovate or slightly pyriform conidia. They appear in spring growing from or near sclerotia. Affected plants do not start spring growth.

Botrytis

► Blights.

Botrytis aclada. **Gray Mold Neck Rot** of onion, also shallot and garlic; widespread. This is usually found on bulbs after harvest, infection taking place through neck tissue and scales appearing sunken and "cooked." Sclerotia are first white, then dark, 2 to 4 mm across. Conidiophores and conidia forming the gray mold are produced directly from mycelium in tissue or from sclerotia. Artificially cure bulbs after harvest to cause rapid dessication of neck tissue; store at low temperature. Colored varieties keep better than white.

Botrytis byssoidea. **Mycelial Neck Rot** of Onion. The fungus is much like *B. aclada* but produces more mycelium and less profuse gray mold.

Botrytis cinerea. **Gray Mold Fruit Rot**, **Cosmopolitan** on peach, cherry, plum, pomegranate, quince, pear, grape, strawberry, pepper, tomato and eggplant. Also causing a leaf rot of hothouse rhubarb and a rot of carrot, lettuce, celery and onion. See further under Blights.

Botrytis gladiolorum. **Botrytis Neck Rot**, **Corm Rot**, **Blight** of gladiolus. ► Blights.

Botrytis porri. Seedborne causing natural infection.

Botrytis (Teleomorph, *Botryotinia*) **squamosa**. **Small Sclerotial Neck Rot** of onion. Elliptical leaf lesions with withering of tips.

Botrytis tulipae. **Bulb Rot** of Vidalia sweet onion.

Brachysporium

Deuteromycetes, Hyphomycetes

Conidiophores brown, erect, usually solitary, septate; conidia dark, unequally two- or more-septate; attached to apical cell of conidiophore by a short narrow cell; saprophytic.

Brachysporium tomato. **Fruit Rot** of tomato.

Calonectria

See *Cylindrocladium* under Blights.

Calonectria crotalariae. **Basal Stem Rot** of oleander.

Calonectria sp. (Anamorph, *Cylindrocladium*). **Crown and Collar Rot** on papaya.

Catenularia

Deuteromycetes, Hyphomycetes

Hyphae dark; conidophores simple or sparingly branched, with terminal chains of conidia; spores dark, one-celled.

Catenularia fuliginea. **Fruit Rot** of date.

Mycocentrospora

Deuteromycetes, Coelomycetes

Spores hyaline, filiform, with long, whiplike tapering beaks, several cross walls and a swordlike appendage from basal cell; mycelium dark.

Centrospora acerina (see *Mycocentrospora acerina*). **Black Crown Rot** of celery, **Storage Rot** of carrot.
Mycocentrospora acerina (formerly *Centrospora acerina*). **Black Crown Rot** of celery, **Storage Rot** of carrot (see Fig. 3.46). On celery the disease appears 7 or 8 weeks after stock has been placed in cold storage with pale, ochraceous lesions at the crown end, gradually turning black, sometimes reddish. The fungus lives in the soil; use infested fields for early celery to be marketed without storage. The same species also causes leaf spot of pansy.

Cephalosporium

► Leaf Spots.

Cephalosporium carpogenum. **Fruit Rot** on apple in storage, reported from Washington and Pennsylvania.
Cephalosporium gregatum (see *Phialophora gregata*). **Brown Stem Rot** of soybean.
Phialophora gregata (formerly *Cephalosporium gregatum*). **Brown Stem Rot** of soybean.
A vascular disease of major importance in the Midwest, also present in Florida, North Carolina and Virginia. It has been controlled with a long rotation – 5 years corn, 1 year soybeans.

Ceratocystis

► Cankers.

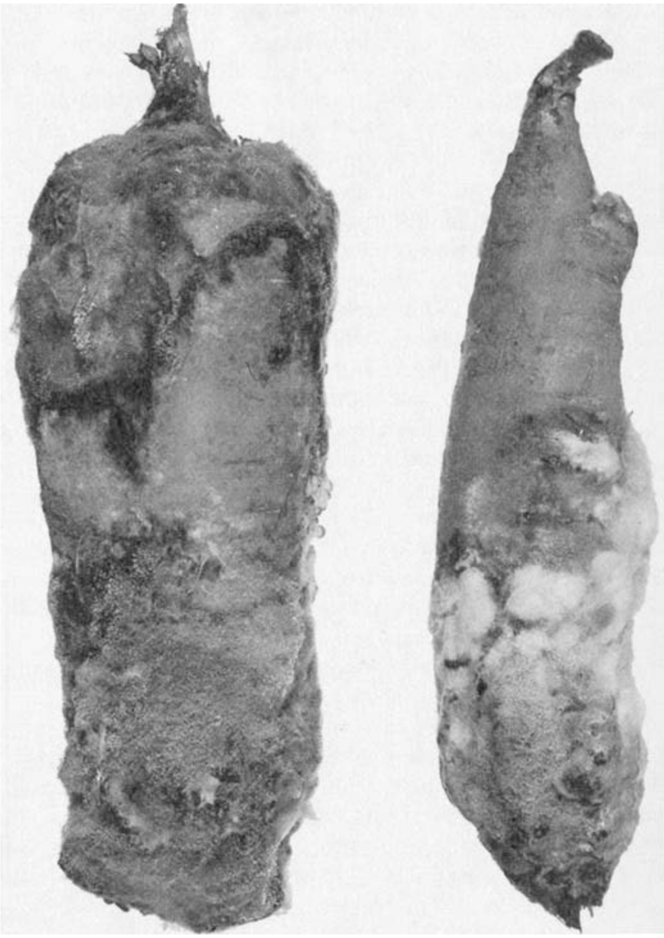


Figure 3.46 Storage Rot on Carrot

Ceratocystis fimbriata (*Endoconidiophora fimbriata*). **Sweet Potato Black Rot**, found wherever sweetpotatoes are grown, most destructive in storage but present also in seedbed and field. Round, blackish spots extend into vascular ring or deeper; sprouts are sickly with black cankers below ground or are killed. The fungus winters in storage houses, on wild morning-glory and other weeds near the field and in soil, where it remains viable for several years. Spores are spread by the sweetpotato weevil and in wash water if potatoes are washed before storing. This fungus also infects *Jacquemontia*.

Control. Standard treatment has been disinfection of planting stock in a solution of borax. Using pulled sprouts provides plants free from black rot. Plan a 4-year rotation; sort carefully before storage; cure quickly at high temperature and humidity. Yellow Jersey is highly susceptible; some varieties are quite resistant.

A strain of this fungus is reported causing **Black Cane Rot** in propagating bed of *Syngonium auritum* (*Philodendron trifoliatum*) in a California nursery. Brown to black water-soaked girdling cankers, often on parts in contact with the soil, cause yellowing and death of foliage. The fungus can be eradicated by treating canes with hot water, 120°F for 30 minutes.

Ceratocystis wageneri (see *Ophiostoma wageneri*). **Root Rot** of lodgepole pine and ponderosa pine.

Ophiostoma wageneri (formerly *Ceratocystis wageneri*). **Root Rot** of lodgepole pine and ponderosa pine.

Apostrasseria (Ceuthospora)

Deuteromycetes, Coelomycetes

Pycnidia in a valsoid stroma; conidia oblong to bacillar, extruded in tendrils; conidiophores obsolete or none.

Apostrasseria lunata (formerly *Ceuthospora lunata*). **Black Rot** of cranberry, developing in berries after picking. The fruit turns dark and soft. The disease is more important in Washington and Oregon. Spraying for other cranberry diseases largely controls this rot. Pick berries when dry; avoid bruises; keep them cool.

Ceuthospora lunata (see *Apostrasseria lunata*). **Black Rot** of cranberry, developing in berries after picking.

Chalara (Chalaropsis)

► Molds.

Chalara thielaviopsis (formerly *Chalaropsis thielaviopsis*). **Root Rot** on poinsettia.

Chalaropsis thielaviopsis (see *Chalara thielaviopsis*). **Root Rot** on poinsettia.

Armillaria (Clitocybe)

Basidiomycetes, Agaricales

One of the mushrooms, with gills typically decurrent (running down the stem), cap homogenous and confluent with fleshy stripe, which has neither ring nor cup; spores white or very lightly colored.

Armillaria tabescens (formerly *Clitocybe monadelpha*). On privet, apple.

Armillaria tabescens (formerly *Clitocybe tabescens*). **Mushroom Root Rot**, **Clitocybe Root Rot** of citrus, pecan and other fruits and many ornamentals. This root rot is as devastating in Florida as Armillaria rot is in California and very similar (some say the pathogen is identical). It is important in the decline of citrus groves, on orange, grapefruit, lemon, tangerine and lime on rough lemon stock; is very destructive to Australian-pine (*Casuarina*); and has been reported on more than 200 species in 59 plant families, including *Acalypha*, avocado, arborvitae, apricot, camellia, castor-bean, cherry-laurel, crape-myrtle, cotoneaster, cypress, dogwood, *Eugenia*, eucalyptus, grape, guava, glorybush, *Hamelia*, holly, *Ligustrum*, juniper, jasmine, loquat, oleander, poinciana, pomegranate, pear, *Parkinsonia*, rose, viburnum and wax-myrtle. In recent years Clitocybe root rot has become economically important on Georgia peach trees and has killed many lychee trees in Florida. It is said to account for 75% of rose mortality in some sections.

Symptoms of decline do not ordinarily develop until the pathogen has been working a number of years and has killed a large part of the root system. Often mushrooms are present at the base of trees before the tops show more than a slight yellowing or lack of vigor; but if soil is removed from the root crown, many lateral roots are found dead, and often the taproot is also gone. Infection starts at some point on the lateral roots, spreads to the base of the tree, and then to other roots. Sometimes there is gumming at the crown extending upward on the trunk. Mycelial fans or sheets are present between bark and wood; the clusters of mushrooms developing at the base are similar to those of *Armillaria*, but the black shoestring rhizomorphs are lacking. Instead, there are sometimes black, hard stromatic outgrowths from fissures in bark of infected roots. The fruiting clusters develop in fall, from mid-September to December. The caps are light tan to honey-colored, 2 to 3 1/2 inches in diameter. The rot is most prevalent on land cleared of oaks and other hardwoods, also on sandy, well-drained land subject to drought.

Control. Citrus trees on sour orange stock are quite resistant. Surgical treatment for fruits and ornamental trees is often quite successful. Remove the soil at least 2 or 3 feet from the trunk, working carefully to avoid injuring healthy roots. Cut off all dead roots, flush with the root crown and remove any infected oak or foreign roots in the vicinity. Cut out dead and infected bark at the root crown or the base of the trunk, being sure to collect all chips (on heavy paper placed under exposed roots) for burning. Paint all exposed surfaces with a pruning wound compound and fill in partially, disinfesting the soil with bordeaux mixture. The root crown can be left exposed to aeration and drying or, if too large a proportion of the root system has been lost, new roots can be stimulated by mounding the soil around the base to a height of several inches above the partial girdle. The new roots will come from callus formed at the margin of living bark.

Trenches 2 or 3 feet deep will aid in preventing spread to healthy trees. Fallow soil can be treated with carbon disulfide; ►*Armillaria mellea.*

Clitocybe monadelpha (see *Armillaria tabescens*). On privet, apple.

Clitocybe tabescens (see *Armillaria tabescens*). **Mushroom Root Rot**, **Clitocybe Root Rot** of citrus, pecan and other fruits and many ornamentals.

Colletotrichum

► Anthracnose.

Colletotrichum acutatum. **Bitter Rot** of apple fruit; fruit rot of grape.

Colletotrichum capsici. **Ripe Rot** of pepper, **Boll Rot** of Cotton.

Colletotrichum circinans. **Onion Smudge**, surface rot, also on shallot, garlic and leek. Bulb or neck has a dark green or black smudge, often covered with stiff bristles of the acervuli of the fungus. Smudge is more prominent in white onions; it is confined to the neck of colored bulbs. The fungus winters on mature onions, on sets or in soil. It develops in the field at a fairly high temperature and soil moisture with most of the damage just before harvest. Cure rapidly after harvest; rotate crops; clean up debris; change to colored onions if the rot is too serious on white.

Colletotrichum coccodes. **Root Rot** and **Wilt** of greenhouse tomato.

Colletotrichum gloeosporioides. **Fruit Rot** of grape and pepper.

Colletotrichum gloeosporioides (formerly *Colletotrichum nigrum*). **Fruit Rot** of pepper, probably general on pepper in South and East. The fungus is a wound parasite on pepper pods. The spots are irregular, indefinite, depressed, blackish. Numerous acervuli with stout setae are scattered over spots.

Colletotrichum lilii. **Black Scale Rot** of Easter lily, **Brown Scale**. First noticed in Louisiana in 1937, the rot immediately threatened the lily industry in that section. Bulbs are brown to nearly black when dug, with outer scales most affected. Young lesions start as irregular light brown areas, then become black and sunken owing to collapse of epidermal cells and subepidermal layers. Oldest lesions are nearly black, with tissue dry and shriveled. Stems and roots are not affected. The acervuli are small, gregarious, with many dark brown setae and continuous hyaline conidia.

Colletotrichum nigrum (see *Colletotrichum gloeosporioides*). **Fruit Rot** of pepper, probably general on pepper in South and East. The fungus is a wound parasite on pepper pods. The spots are irregular, indefinite, depressed, blackish. Numerous acervuli with stout setae are scattered over spots.

Frammulina (Collybia)

Basidiomycetes, Agaricales

Margin of young cap turned in; gills not decurrent; stipe central; no annulus or volva; spores white or light; causing wood rots.

Collybia velutipes (see *Frammulina velutipes*). **Heart Rot**, **White Sapwood Rot** of hardwoods.

Frammulina velutipes (formerly *Collybia velutipes*). **Heart Rot**, **White Sapwood Rot** of hardwoods. The fungus is a small toadstool with central stem, base covered with dark brown velvety hairs, cap yellowish or brownish. The disease is a soft spongy white rot of sapwood of living hardwoods, particularly basswood, horse-chestnut, American elm and on catalpa. The toadstools are formed in clusters at wounds.

Coniophora

Basidiomycetes, Aphyllophorales

Pileus resupinate, effuse; hymenium with one layer, cystidia lacking; spores dark; wood-destroying.

Coniophora puteana. **Brown Cubical Rot** of conifers and sometimes hardwoods – on slash, building timbers, and sometimes living trees. The crustlike fleshy fruiting bodies are a little over 2 inches in diameter, olive to brown with whitish margins and smooth to slightly waxy surface.
Coniophora corrugis (see *Cylindrobasidium corrugum*). **Sapwood Rot** of alpine fir.
Cylindrobasidium corrugum (formerly *Coniophora corrugis*). **Sapwood Rot** of alpine fir.

Coniella (Coniothyrium)

► Cankers.

Coniella diplodiella (formerly *Coniothyrium diplodiella*). **White Rot** of grapes, appearing spasmodically on grapes but not one of the more important diseases. Small pycnidia appear on outside of fruit cuticle as shiny, rosy points, also on leaves. Infection is usually through wounds. Spots on ripe grapes are grayish, with brown borders.
Coniothyrium diplodiella (see *Coniella diplodiella*). **White Rot** of grapes, appearing spasmodically on grapes but not one of the more important diseases.

Coprinus

Basidiomycetes, Agaricales

Inky cap mushrooms; hymenium lining gills; gills deliquesce into a black, inky liquid.

Coprinus urticicola. **Fruit Rot** of pear.

Corticium

Basidiomycetes, Aphyllophorales

Pileus resupinate, effuse; hymenium with one layer, cystidia lacking; spores hyaline. *Corticium vagum* and other species with a thin film of mycelium with short, broad cells on substratum have been transferred to *Pellicularia*. Species with cystidia have been placed in *Peniophora*. See also *Corticium* under Blights.

Butlerelfia eustacei (formerly *Corticium centrifugum*). **Fisheye Fruit Rot** of apple, generally distributed. A dry, spongy rot often following scab.

Corticium centrifugum (see *Butlerelfia eustacei*). **Fisheye Fruit Rot** of apple, generally distributed.

Corticium fuciforme (see *Laetisaria fuciformis*). **Pink Patch** of turf, red thread.

Corticium galactinum (see *Scytinostroma galactinum*). **White Root Rot** of apple, also recorded on blackberry, dewberry, wineberry, peach and many ornamentals – baptisia, dogwood, holly, flowering almond, flowering plum, iris, winter jasmine, kalmia, pearl bush, peony, spirea, sumac, viburnum and white campion.

Corticium radiosum (see *Vesiculomyces citrinus*). **White Butt Rot** on subalpine fir in Colorado.

Laetisaria fuciformis (formerly *Corticium fuciforme*). **Pink Patch** of turf; red thread. Grass is first water-soaked, then dead, in isolated patches, 2 to 15 inches in diameter, with pinkish red gelatinous strands of the fungus matting the blades together and growing into coral red horns, 1/8 to 2 inches long. These turn brittle, break into pieces to spread the pathogen. Velvet bent grasses are more susceptible than colonial and creeping bents. Cadmium compounds will control if applied as protectants before the disease appears.

Scytinostroma galactinum (formerly *Corticium galactinum*). **White Root Rot** of apple, also recorded on blackberry, dewberry, wineberry, peach and many ornamentals – baptisia, dogwood, holly, flowering almond, flowering plum, iris, winter jasmine, kalmia, pearl bush, peony, spirea, sumac, viburnum and white campion. The fungus also causes a root rot of white pine and a decay of firs, affecting also western white cedar and spruce. The disease starts at the collar or on larger roots and advances rapidly outward on smaller roots. The collar may be girdled and killed while distal portions are still alive. A dense weft of white mycelium covers roots and penetrates to wood, causing the white rot. The disease is prevalent on lands recently cleared of oaks.

Vesiculomyces citrinus (formerly *Corticium radiosum*). **White Butt Rot** on subalpine fir in Colorado.

Corynespora

► Leaf Spots.

Corynespora cassiicola. **Root Rot** on soybean.

Cryptochaete

Basidiomycetes, Aphyllophorales

Basidocarp cartilaginous or coriaceous, erumpent, at first tuberculiform; gloecystidia yellowish or hyaline; cystidia present or lacking; spores hyaline, curved-cylindrical to allantoid, smooth.

Cryptochaete (Corticium) polygonia (see *Peniophora polygonia*). **White Rot** on aspen in Colorado.
Peniophora polygonia (formerly *Cryptochaete* (*Corticium*) *polygonia*). **White Rot** on aspen in Colorado.

Cylindrocarpon

Deuteromycetes, Coelomycetes

Conidia on sporodochia; spores with several cells, like *Fusarium* but more nearly cylindrical with rounded ends; cosmopolitan in soil, occasionally pathogenic.

Cylindrocarpon liriodendri. **Root Rot** of tulip poplar.
Cylindrocarpon destructans. Sometimes listed as cause of Scale-Tip Rot of Easter lily in Pacific Northwest, but probably secondary. True cause of rot unknown.

Cylindrocladium

► Blights.

Cylindrocladium clavatum. **Root Rot** on Norfolk-island-pine.
Cylindrocladium crotalariae (Teleomorph, *Calonectria crotalariae*). **Cylindrocladium Black Rot** on peanut, and **Root Rot** on tulip tree and kiwi. Red crown rot; on soybean.
Cylindrocladium scoparium. **Root Rot** on peach and tulip-tree.
Cylindrocladium heptaseptatum. **Postharvest Decay** on leatherleaf fern.
Cylindrocladium pauciramosum. **Root and Crown Rot** on heath.
Cylindrocladium parasiticum. **Black Rot** of hoary-tick clover and on peanut.
Cylindrocladium pteridis. **Postharvest Decay** on leatherleaf fern.

Cylindrocladium scorparium. **Root Rot** on pine, sweet gum and tuliptree.

Daedalea

Basidiomycetes, Aphyllophorales

Pileus dimidiate to caplike and stipitate; pores waved, mazelike or somewhat resembling gills; without cystidia; hymenium labyrinthine.

Cerrena unicolor (formerly *Daedalea unicolor*). **Heart Rot**, **Canker** of maples and other living hardwoods, including alder, ailanthus, amelanchier, birch, chestnut and hackberry. Decayed wood is yellow at first, later white and soft. Conks are small, corky, often occuring in clusters, varying from brown to gray.

Daedalea confragosa (see *Daedaleopsis confragosa*). **White Mottled Wound Rot** of hardwoods, also on fir.

Daedalea quercina. **Brown Cubical Rot** of dead timber; **Heart Rot** of living trees in immediate vicinity of butt wounds, usually on oak, chestnut, sometimes on maple, birch and hickory. In advanced stages the wood is reduced to a yellow-brown friable mass, with a tendency to break into small cubes. Conks are corky and shelf-shaped, up to 7 inches wide, grayish to almost black with smooth upper surface and cream to brownish undersurface. Mouths are large, elongated, irregular. The conks are more or less perennial.

Daedalea unicolor (see *Cerrena unicolor*). **Heart Rot**, **Canker** of maples and other living hardwoods, including alder, ailanthus, amelanchier, birch, chestnut and hackberry.

Daedaleopsis confragosa (formerly *Daedalea confragosa*). **White Mottled Wound Rot** of hardwoods, also on fir. This is a white soft rot, a slash destroyer in eastern hardwood forests but sometimes on living trees, especially willows, near wounds. Annual leathery to rigid conks (sporophores) are shelf-shaped, up to 6 inches wide, and may occasionally encircle a small, dead stem. The upper surface is gray to brown, smooth, concentrically zoned. Mouths of tubes on undersurface are elongated, wavy in outline.

Daldinia

Ascomycetes, Xylariaceae

Perithecia in a globoid to pulvinate, concentrically zoned stroma, carbonaceous to leathery, 3 to 5 cm across; spores one-celled; dark.

Daldinia concentrica. **Wood Rot** of ash, beech, various hardwoods and occasionally citrus. There is a superficial white rot on dead parts of living trees. On English ash the decay is called calico wood and is strikingly marked with irregular brown to black bands. Stroma containing perithecia are hemispherical, black, carbonaceous.

Diaporthe

► Blights.

Diaporthe phaseolorum. **Sweetpotato Dry Rot**. If diseased potatoes are planted, the sprouts are affected, but the disease shows little in the field. The roots, infected at the stem end, continue to rot in storage. They are shrunken, often mummified, covered with papillae, which are pycnidia under the skin massed in a coal-black stroma. Optimum temperature for the fungus is 75° to 90°F. Use cool storage.

Diaporthe citri. **Phomopsis Stem End Rot**, **Melanose**, general on citrus; Stem Rot of mango. The rot on fruits is a leathery, pliable, buff to brown area at the button end. The melanose is a superficial marking of fruits with yellow or brown, scabby, waxy dots or crusts, on leaves, twigs and fruit, often in streaks. On lemon trees, especially variety Eureka, there is a condition known as decorticosis or shell bark. The outer bark dies, loosens, peels off in longitudinal strips. New bark forms below this, and the tree may recover only to develop the disease again in 4 or 5 years. Some leaves and twigs die; the fungus winters in dead wood.

Control. A single copper spray, bordeaux or a neutral copper, applied within 1 to 3 weeks after fruit is set, controls melanose. Copper applied in summer induces excessive cork formation in the melanose lesions, a condition known as star melanose. Applied early, it is noninjurious.

Diaporthe phaseolorum. **Fruit Rot** of pepper and tomato, also pod blight of lima bean. ► Blights.

Dichotomophthora

► Cankers.

Dichotomophthora portulacae. **Black Stem Rot** on common purslane.

Diplodia

► Blights.

Diplodia natalensis (see *Lasiodiplodia theobromae*). **Diplodia Collar** and **Root Rot**, **Fruit Rot**, **Gummosis**, general on citrus, sometimes peach, mango and avocado.

Diplodia opuntia. **Cladode Rot** of cactus.

Diplodia phoenicum. **Leaf and Stalk Rot** of date palms, **Fruit Rot**. The disease is sometimes fatal to transplanted offshoots. Leaves decay and die prematurely; spores are produced in great abundance. Infection is through wounds. Remove diseased tissue as far as possible and apply copper-lime dust.

Diplodia pinastri. **Collar Rot** of pine.

Diplodia theobromae (see *Lasiodiplodia theobromae*). Sometimes considered a synonym of *D. natalensis*.

Diplodia tubericola (see *Lasiodiplodia theobromae*). **Java Black Rot**, general on sweetpotatoes, especially in the South.

Diplodia zeae (see *Stenocarpella maydis*). **Diplodia Corn Ear Rot**, **Root and Stalk Rot**, seedling blight.

Lasiodiplodia theobromae (formerly *Diplodia natalensis*). **Diplodia Collar and Root Rot**; **Fruit Rot**, **Gummosis**, general on citrus, sometimes peach, mango and avocado. On fruit, the rot resembles Phomopsis rot in being a leathery pliable decay of the stem end. It can be prevented by spraying with bordeaux mixture, adding 1% oil to check the increase in scale insects after the copper kills entomogenous fungi keeping them in check. The collar rot may girdle young trees and produce some gumming. Trees affected with root rot seldom recover and should be removed.

Lasiodiplodia theobromae (formerly *Diplodia theobromae*). Sometimes considered a synonym of *D. natalensis* but differentiated by pycnidia developed in a stroma instead of on a subiculum and by darker spores. Causing rots of tropical fruits, stem-end rot of avocado and collar rot of peanuts. The peanut rot appears in Georgia, Florida and Alabama. Runners and central stem are invaded; they are brown at first, then black with pycnidia.

Lasiodiplodia theobromae (formerly *Diplodia tubericola*). **Java Black Rot**, general on sweetpotatoes, especially in the South. So named because the first diseased specimens came from Java; this is strictly a storage rot. The inner part of the tuber is black and brittle; innumerable pycnidia are produced under the skin, giving it a pimply appearance. The potato is finally mummified. Use care in handling so skins are not broken or bruised; cure properly after harvest; have suitable temperature in the storage house.

Stenocarpella maydis (formerly *Diplodia zeae*). **Diplodia Corn Ear Rot**, **Root and Stalk Rot**, seedling blight. This is one of several fungi commonly causing ear rot in corn. The rot is dry, varying from a slight discoloration of kernels to complete rotting of the ear. Seedlings and inner stalks have a dry, brown decay. Another species (*D. macrospora*) is similar but less common, found in more humid, warmer regions. The rot is greater in smutted plants. Treat seed before planting with Spergon.

Diplodina

► Leaf Spots.

Diplodina persicae. **Fruit Rot** of peach, found in Louisiana in 1952, affecting stem and leaves as well as fruit. All varieties are susceptible.

Epicoccum

► Leaf Spots.

Epicoccum nigrum. **Postharvest Decay** on cantaloupe.

Echinodontium

Basidiomycetes, Aphyllophorales

Hymenium in the form of teeth with spiny serrate margins; pileus caplike to crustose.

Echinodontium tinctorium. The Indian paint fungus causes **Brown Stringy Rot**, **Heartwood Rot** of living conifers – balsam fir, hemlock, Engelmann spruce, larch, and Douglas-fir – chiefly in the West, often with large losses in forest stands. Light brown to tan spots are produced in heartwood accompanied by small radial burrows resembling insect galleries. Rusty streaks follow the grain. In older trees rot can extend entire length of heartwood and into roots. External signs of decay are hard, woody, hoof-shaped perennial conks, the upper surface dull black, cracked, the undersurface gray, covered with coarse teeth, the interior rust are brick red with a pigment used by the Indians for paint. Even one fruiting body is indicative of extensive decay.

Polyporus (Favolus)

Basidiomycetes, Aphyllophorales

Pileus usually stipitate; lamellae forking irregularly to form elongate, rhomboidal pores.

Favolus alveolaris (see *Polyporus mori*). **Heart Rot** of hickory.
Polyporus mori (formerly *Favolus alveolaris*). **Heart Rot** of hickory.

Fomes

Basidiomycetes, Aphyllophorales

Pileus woody, perennial, with tubes in layers; common cause of wood decay. Spores hyaline to brown to nearly black.

Fomes annosus (see *Heterobasidion annosum*). **Heart Rot**, **Root and Butt Rot**, **Spongy Sap Rot** of conifers, sometimes hardwoods; also **Root Rot** on juniper and rhododendron.
Fomes applanatus. ► *Ganoderma applanatum.*
Fomes connatus. **White Spongy Rot** of heartwood of living hardwoods, most prevalent on maples, especially red and sugar maples. Entrance is through wounds or branch stubs, but fruiting is usually on basal stems or scars. Conks appear annually but are perennial, small, less than 6 inches wide, hoof-shaped, corky to woody, white to yellowish, the upper surface covered with moss or algal growth. There is usually a limited area of decay.
Fomes everhartii (see *Phellinus everhartii*). **Yellow Flaky Heart Rot** of living hardwoods, including birch and beech and especially oaks.
Fomes fomentarius. **White Mottled Rot** of birch, beech, poplar, maple, and other hardwoods. This fungus mostly decays dead timber; sometimes it attacks living trees. The wood is brownish, firm in early stages of decay, but in advanced stages is yellowish white, soft, spongy, with narrow dark zone lines and small radial cracks filled with yellow mycelium, giving a mottled effect. Decay starts in upper part of the bole and progresses downward. Conks are profuse on dead trees. They are hard, perennial, hoof-shaped, up to 8 inches wide, with a smooth concentrically zoned upper surface, gray to

brown undersurface. The interior is brown, punky, with tubes encrusted with white.

Fomes fraxinophilus (see *Perenniporia fraxinophila*). **White Mottled Rot** of ash, a heartwood rot most common on white ash, also on green ash and willow.

Fomes igniarius (see *Phellinus igniarius*). **White Spongy Rot**, **White Trunk Rot**, **Heart Rot**, on a wide variety of hardwoods but not on conifers.

Fomes officinalis (**Fomitopsis officinalis**) (see *Fomitopsis officinalis*). **Brown Trunk Rot** of conifers infecting heartwood of living larch and other trees.

Fomes pini (**Trametes pini**) (see *Phellinus pini*). **Red Ring Rot**, white pocket rot, of conifers, especially Douglas-fir, larch, pine and spruce, causing heavy forest losses.

Fomes pinicola (see *Fomitopsis pinicola*). **Brown Crumbly Rot** of many conifers and some hardwoods – maple, birch, beech, hickory, peach – sually on dead trees, occasionally in heartwood of living trees.

Fomes rimosus (see *Phellinus robiniae*). **Heart Rot** on locust.

Fomes robustus (see *Phellinus robustus*). **Heart Rot** of cacti and other desert plants; of oak, fir, juniper, in different strains.

Fomes roseus (see *Fomitopsis rosea*). **Brown Pocket Rot**, cubical rot of heartwood of living conifers, particularly Douglas-fir.

Fomitopsis officinalis (formerly *Fomes officinalis* (*Fomitopsis officinalis*)). **Brown Trunk Rot** of conifers infecting heartwood of living larch and other trees. Intensely white spore surface; very bitter, known as the quinine fungus.

Fomitopsis pinicola (formerly *Fomes pinicola*). **Brown Crumbly Rot** of many conifers and some hardwoods – maple, birch, beech, hickory, peach – ually on dead trees, occasionally in heartwood of living trees. Sporophores are shelf- to hoof-shaped, 2 to 10 inches across, sometimes up to 2 feet, upper surface gray to black, often with a red margin, underside white to yellow when fresh.

Fomitopsis rosea (formerly *Fomes roseus*). **Brown Pocket Rot**, cubical rot of heartwood of living conifers, particularly Douglas-fir. Decay originates in upper part of bole. Wood is yellow to reddish brown, soft, breaking into irregular cubes. Woody bracket conks, up to 6 inches wide, have black tops and rose undersurface. Infection is through dead branch stubs and broken tree tops.

Heterobasidion annosum (formerly *Fomes annosus*). **Heart Rot**, **Root and Butt Rot**, **Spongy Sap Rot** of conifers, sometimes hardwoods; also

Root Rot on juniper and rhododendron. Infection is through wounds. Tissue thin, mycelial felts are formed between bark and wood, which is pinkish to violet in incipient states. In advanced stages white pockets are formed in wood. Perennial conks are bracket-shaped to flat layers, upper surface zonate, light to dark grayish brown, undersurface beige with small pores. Infection is sometimes through dead roots from mycelium growing through soil, sometimes by spores washed by rain or carried by rodents.

Perenniporia fraxinophila (formerly *Fomes fraxinophilus*). **White Mottled Rot** of ash, a heartwood rot most common on white ash, also on green ash and willow. Conks are up to a foot wide, with dark, rough upper surface, brownish underneath, appearing first when wood has decayed only a short distance. Infection is usually through branch stubs.

Phellinus everhartii (formerly *Fomes everhartii*). **Yellow Flaky Heart Rot** of living hardwoods, including birch and beech and especially oaks. Infection is usually limited to the lower trunk, and the flaky character is because the decay is more rapid between rays. There are narrow, dark brown zone lines. Gnarled swellings on the trunk indicate sapwood invasion. The conks are perennial, hard, woody, shelf-shaped, up to a foot wide, with the yellow-brown upper surface becoming black, charred, rough, concentrically grooved with age. The undersurface is reddish brown.

Phellinus ingiarius (formerly *Fomes igniarius* (*Phellinus igniarius*)). **White Spongy Rot**, white trunk rot, heart rot, on a wide variety of hardwoods but not on conifers. Aspen and birch are particularly susceptible. Decay is mostly confined to heartwood, but in yellow birch living sapwood is killed, causing cankers on the trunk. In an advanced stage the decay is soft, whitish, with fine black lines running through it. The conks are perennial, hard, woody, thick, usually hoof-shaped, up to 8 inches wide, the upper surface gray to black, becoming rough and cracked with age; undersurface is brown and the interior rusty brown with many layers of tubes, the oldest stuffed with white. Infection is through branch stubs and open wounds. A single conk may indicate 15 linear feet of rot in heartwood.

Phellinus pini (formerly *Fomes pini* (*Trametes pini*)). **Red Ring Rot**, white pocket rot, of conifers, especially Douglas-fir, larch, pine and spruce, causing heavy forest losses. Decay starts as a purplish or red discoloration of the heartwood, but in an advanced stage there are many soft, white fibrous pockets separated by sound wood. Sporophores vary from shelf- to bracket- to hoof-shaped, averaging 4 to 8 inches across, rough gray to brownish black with light brown margin on upper surface and gray to brown underneath.

Tube mouths are circular to irregular. On living trees conks are formed at knots or branch stubs.

Phellinus robiniae (formerly *Fomes rimosus*) **Heart Rot** on locust.

Phellinus robustus (formerly *Fomes robustus*). **Heart Rot** of cacti and other desert plants; of oak, fir, juniper, in different strains. Context of sporophores bright yellow-brown; spores hyaline.

Fusarium

Deuteromycetes, Coelomycetes

Mycelium and spores generally bright in color. Macroconidia fusoid-curved, septate, on branched conidia in slimy masses, sporodochia; smaller microconidia with one or two cells; resting spores, chlamydospores, common. Teleomorph state when known usually in Hypocreales, *Nectria* or *Gibberella*. Cause of many important rots, wilts, and yellows diseases. Classification difficult, with different systems and synonyms, many forms and races. (see Fig. 3.47)

Fusarium acuminatum. **Fruit Rot** of squash and pumpkin.

Fusarium avenaceum. **Crown Rot** of Eustoma. Associated with cereal diseases, fruit and storage rots, but now included in *F. roseum* by many pathologists. **Fruit Rot** of squash and pumpkins.

Fusarium culmorum. Also on cereals, included in *F. roseum* by many pathologists. **Fruit Rot** of squash and pumpkins, also **Root and Basal Rot** of leak.

Fusarium equiseti. **Fruit Rot** of squash and pumpkin.

Fusarium moniliforme (Teleomorph, *Gibberella fujikuroi*). **Ripe Rot** of figs, carried by the pollinating fig wasp; **Root, Stalk, Pink Kernel Rot** of corn. The rotted kernels are pink to reddish brown; the stalks have brown lesions, may break over or ripen prematurely.

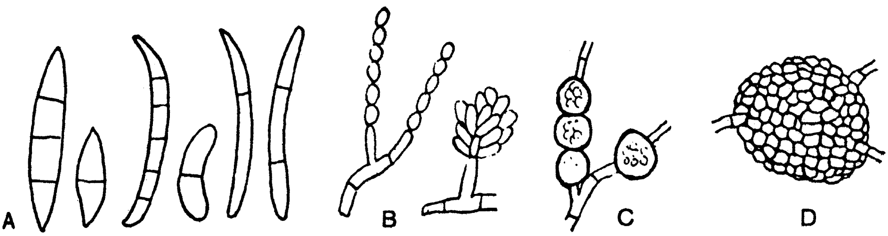


Figure 3.47 Forms of *Fusarium*. **A** septate macroconidia; **B** micoconidia in chains or a head; **C** clamydospores; **D** sclerotium

Fusarium oxysporum. Reported as causing a new disease of soybean in Missouri and Iowa. Root rot, with rapid wilting and drying of leaves; most severe on seedlings.

Fusarium oxysporum. **Root Rot** on apple and sage; tomato hypocotyl rot on sugar pine, red and white firs; stem rot on zygocactus; and rot of stone plant. This pathogen may also be seedborne and pathogenic on Douglas-fir. Root and crown rot; of leafy spurge.

Fusarium oxysporum. **Iris Basal Rot** on bulbous varieties of iris. Plants fail to emerge, or turn yellow, wilt and die. Roots are few or none. The bulb is infected at the base, which shrinks; the husk adheres firmly, sometimes with a white or reddish mass of mycelium. The rot is more serious in warm climates and on yellow rather then blue varieties. De Wit is very susceptible; Wedgewood is quite resistant.

Control. Avoid bruising bulbs in digging; sort and discard diseased bulbs right after digging; dry bulbs rapidly.

Fusarium oxysporum. **Tulip Basal Rot**. Leaves growing from diseased bulbs turn red, wilt and die; roots are few or none. Bases of bulbs have a rather firm rot with white or pink felty masses of spores. The diseased area usually turns chalky. This is primarily a storage disease in bulb sheds and warehouses.

Fusarium oxysporum f. sp. **batatas**. **Sweetpotato Stem Rot**, a widespread field disease, destroying more than 50% of plants in some fields. This fungus also infects *Jacquemontia*. The stem rot is conspicuous about 2 weeks after sprouts are set. Sprouts are yellow or dead, and the vines brown or black, often split near the ground. Some plants develop new roots above the decayed section and so survive. Sweetpotatoes from infected plants are small, decayed at the stem end, with vascular tissues brown. The fungi winter in stored roots and can live indefinitely in soil. Varieties Big Stem Jersey, Little Stem Jersey, Maryland Golden and Nancy Hall are very susceptible; Porto Rico is intermediate; Southern Queen, Triumph, and Yellow Strassburg are quite resistant.

Fusarium oxysporum f. sp. **cepae**. **Bulb Rot**, **Basal Rot** of onion, shallot and garlic. In the field there is progressive yellowing and dying back from tips, the roots commonly turning pink and gradually decaying. The rot is often associated with wounds of maggots and other insects. In storage the rot is most active at room temperature or above.

Fusarium oxysporum f. sp. **chrysanthemi**. **Fusarium Wilt** of chrysanthemum.

Fusarium oxysporum f. sp. **gladioli** (*F. orthoceras* var. *gladioli*). **Fusarium Brown Rot**, **Yellows** of gladiolus, a major disease in some sections. Most infection takes place in the field, but subsequent decay appears in storage. Corm lesions are first small, reddish brown, more often on lower half of corm. They enlarge in storage to irregular to circular, sometimes zonate brown areas, which do not infrequently advance until the whole corm is a hard, dry, brownish black mummy. Infection comes from old corms, the fungus penetrating through the basal plate and the center of the new corm. The latter may be entirely decayed in storage, with the fungus advancing from the center to the outside, causing brown to black surface lesions.

Symptoms of yellows, a vascular disease, include bending of young leaf stalks, cupping of leaf stalks in older plants, crooked flower stems, often greener than normal and a curving of growth away from the side of the corm showing rot. There is gradual yellowing and dying of foliage, starting with the oldest leaves. Picardy and Spotlight varieties are particularly susceptible. Nitrogenous fertilizers and manures, especially where phosphorus is low, increase corm rot.

Control. Cure immediately after digging at 95°F to develop wound periderm and cuticle resistant to the fungus; use resistant varieties where possible or a 3- to 4-year rotation.

Fusarium oxysporum f. sp. **lilii**. **Basal Rot** of lily, on bulbs, roots, stems of garden and native lilies; **Corm Rot** of crocus, also on freesia and cactus (*Cereus*). A chocolate rot at base of scales next to the basal plate progresses until the scales fall away. The disease is more destructive to Madonna and some other garden lilies; it is seldom a problem with Easter lilies grown in the Northwest. Keep bulbs cool in storage, and plant in cool soil. Infection comes from contaminated soil as well as diseased bulbs.

Fusarium oxysporum f. sp. **narcissi** (*F. bulbigenum*). **Narcissus Basal Rot**, general on hardy varieties, rare on polyanthus varieties. Rot begins at the root plate at base of bulbs and spreads through central portions first, extension of the rot being more rapid in affected scales than across to adjacent healthy scales. Rotted tissue is chocolate or purplish brown, the mycelium a delicate weft of white or pink threads. The rot is dry, spongy, with little external evidence; it is primarily a storage or transit disease, but it may occur in the field late in the season. When lightly infected bulbs are planted, there is no root development, and plants are stunted. Basal rot is spread in hot-water treatment for nematodes. It is more prevalent where soil temperatures are above 65°F and on large trumpet varieties. Golden Harvest is much more susceptible than King Alfred.

Control. Discard all bulbs showing rot, or that are soft when pressed; if disease has occurred previously, plant in a new location.

Fusarium oxysporum f. sp. **radicis-lycopersici**. **Root and Crown Rot** of tomato.

Fusarium oxysporum var. **redolens**. **Root Lesions** of pine.

Fusarium poae. **Carnation Bud Rot**, **Silver Spike Disease** of bluegrass. The interior of carnation buds is brown or pink, decayed, moldy and often infested with grass mites, which have introduced the spores. The disease is favored by excessive dampness. Pick and destroy diseased buds; control mites.

On bent grasses, fescues and especially Kentucky bluegrass, seed heads wither before they are fully expanded, appearing silvery. Seeds are aborted, and in moist weather copious mycelium grows from decayed areas in culms. The pathogen is disseminated and grass inoculated by the grass mite (*Siteroptes graminum*). Burning over dead grass is a practical means of control.

Fusarium proliferatum. **Root Rot** and **Stem Wilt** on asparagus in CT. **Root Rot** and **Crown Rot** of clovers and leafy spurge, **Bulb Rot** of onions.

Fusarium roseum. **Peppermint Root** and **Rhizome Rot**. Reported from Oregon as part of a complex with *Rhizoctonia solani* and *Pythium* sp. Necrotic lesions girdle rhizomes; new shoots damp-off. Fall-plowed mint gave stronger stands. This pathogen also causes seedling stem rot on Douglas-fir.

Fusarium cerealis. **Stem Rot** of carnation and cereals. Roots and stems of cuttings and young plants rot; in older stock the diseased tissue turns brownish red or crimson. Infection is only through injured, weak or old tissue.

Fusarium semitectum. **Corky Dry Rot** on cantaloupe.

Fusarium solani. **Tuber Rot** on caladium and **Stem Rot** on chrysanthemum, Fraser fir, Douglas-fir, dieffenbachia (cutting rot), and sweetpotato (root rot); shefflera is susceptible with no symptoms. Root rot; this pathogen also causes root rot of apple. **Root and Crown Rot** of leafy spurge.

Fusarium solani (Teleomorph, *Nectria haematococca*). **Stem Rot** and **Wilt** of *Exacum*.

Fusarium solani f. sp. **cucurbitae** (Teleomorph, *Hypomyces solani*). **Fusarium Root Rot** of cucurbits, primarily pumpkin and squash, occasionally muskmelon, watermelon and cucumber. The fungus usually girdles the plant at ground level with a soft dark decay, resulting in a striking wilt of the entire vine. Fruits on the ground may be rotted and the fungus carried on seed to infest clean soil. Do not plant cucurbits in land known to be contaminated.

Fusarium solani f. sp.**phaseoli**. **Dry Root Rot** of bean and lima bean, common but most important in New York, Idaho and other areas intensively cropped for many years. Indefinite reddish lesions or streaks on taproot and subterranean stem turn dark brown to black. Lateral roots are reduced and plants stunted. This is a late season disease favored by warm soil. The fungus winters in crop refuse and soil and may be carried in dust on seed. The best control is a long rotation between crops.

Fusarium solani f. sp. **pisi**. **Root Rot** on chick-pea, spruce, pine, fir, and hemlock.

Fusarium subgutinans. **Collar Rot** and **Foliar Blight** on Chinese evergreen.

Fusarium sp. **Root and Seed Rot** of bird-of-paradise (*Strelitizia*), part of a fungus complex. Controlled by treating seed in hot water, 135°F for 30 minutes, and immediately cooling in cold water and treating planting medium with methyl bromide or steam.

Fusarium sp. **Dill Root Rot**, **Wilt**, discovered in Ohio in 1949. Symptoms include browning of roots, necrosis of vascular system, yellowing, wilting and death. Young plants are most susceptible. Seed treatment did not give satisfactory control.

Fusarium sp. **Root Rot** of sweet peas, reported as prevalent in Montana. Plants turn yellow when in bloom with necrosis of vascular system which leads to drying up of plant.

Gaeumannomyces

Gaeumannomyces graminis var. **graminis**. **Blight** of centipede grass and Bermudagrass. Root rot; of St. Augustinegrass. Leaf yellowing and root mass reduction; of Zoysia.

Ganoderma

Basidiomycetes, Aphyllophorales

Differing from *Fomes* in having spores truncated at one end and two-layered, the spines of the brown endospore projecting into hyaline exospore. Sporophore has a hard crust, formed by a layer of thick-walled, elongated cells.

Ganoderma applanatum (Syn. *Fomes applanatus*). **White Mottle Rot**, widely distributed on hardwoods, maple, beech, alder, acacia, birch, horse-chestnut, hawthorn and hickory, and sometimes on conifers. The rot is ordinarily on dead timber, but the fungus can attack living trees through wounds and destroy heartwood for a few feet. In early stages the wood is somewhat bleached, surrounded by a dark brown band. This shelf fungus is called artists' conk because the white undersurface immediately turns brown when bruised and can be used for writing or etching pictures. The upper surface is smooth, zoned, gray or gray-black; up to 2 feet wide.

Ganoderma curtisii (see *Ganoderma lucidum*). Perennial, with several layers of pores.

Ganoderma lucidum (formerly *Ganoderma curtisii*). Perennial, with several layers of pores.

Ganoderma lucidum (Syn. Polyporus lucidus). The varnish or lacquer fungus causes **Heart Rot** of eastern hardwoods and conifers, especially hemlock, reported also on boxwood, hackberry, sassafras, maples and citrus. This fungus may be an important facultative parasite on city shade trees. The rot is white, spongy, with black spots scattered throughout. The conks are annual, with a reddish, shiny, lacquered upper surface and a short, thick lateral stalk; common on logs, stumps, standing or fallen trees.

Ganoderma zonatum. **Butt Rot** of queen palms, Florida.

Ganoderma zonatum. On mesquite, in Texas.

Greeneria

Deuteromycetes, Coelomycetes

Greeneria uvicola. **Bitter Rot** of grape.

Gibberella

► Blights.

Gibberella zeae (Anamorph, *Fusarium graminearum*). **Corn Root Rot**, **Stalk Rot**, **Ear Rot**, also **Fusarium Head Blight** or **Scab** of cereals and grasses. Corn is attacked at all ages, with both roots and kernels rotted. Conidia are pinkish in mass; black perithecia are numerous on overwintered corn stalks and residues. Hybrid corn with loose husks exposing the ear tip or varieties with upright ears retaining water are more apt to be infected. Rotation and clean plowing aid in control.

Gilbertella

Zygomycetes, Mucorales

Gilbertella persicaria. **Fruit Rot** on peach.

Gloeosporium

► Anthracnose.

Colletotrichum gloeosporioides (formerly *Gloeosporium foliicolum*). (*Glomerella cingulata*). **Fruit Rot** on citrus fruits.
Gloeosporium foliicolum (see *Colletotrichum gloeosporioides*). (*Glomerella cingulata*). **Fruit Rot** on citrus fruits.

Gloeotinia

Gloeotinia granigera (formerly *Gloeotinia temulenta*). **Blind Seed Rot** on grass.
Gloeotinia temulenta (see *Gloeotinia granigera*). **Blind Seed Rot** on grass.

Glomerella

► Anthracnose.

Glomerella cingulata. **Bitter Rot** of apple and pear, **Fruit Rot** of peach, also **Stem Rot**, **Canker**, **Dieback** of many fruits and ornamentals, Ripe Rot of grapes. Bitter rot is a late season disease of apple, often destructive in central and southern states. The fruits have light brown circular spots, which gradually enlarge; they cover rotting flesh, which has a bitter taste. Lesions become concave and have concentric rings of pink to dark spore pustules in sticky masses. Spores are splashed by rain or carried by flies and other insects. Eventually apples turn into dry, shriveled mummies, in which the fungus overwinters and where the ascospore stage is produced. Large limbs have oval, roughened, sunken cankers. The disease is favored by hot muggy weather.

Apple varieties vary greatly in resistance, and some, like Yellow Newtown, are resistant to the canker but susceptible to fruit rotting. Varieties somewhat resistant include Delicious, Rome Beauty, Stayman Winesap, Winesap and York Imperial. Ripe rot starts on grapes as they mature and gives a bitter taste to the pulp. To control disease remove mummies from trees and prune out dead twigs and cankers.

Glomerella cingulata var. **vaccinii**. **Cranberry Bitter Rot**, a field and storage rot. A soft brownish yellow discoloration develops on fruit late in the season, most serious in a hot July and August.

Godronia

Ascomycetes, Helotiales

Apothecia coriacious, pitcher-shaped; spores filiform, hyaline.

Godronia cassandrae (*Fusicoccum putrefaciens*). **Cranberry End Rot**, general on cranberry, with the ascospore stage also found on dead branches of leatherleaf (*Cassandra*). The rot appears late, often after picking and packing, and is enhanced by injuries during harvesting and screening. It starts at either blossom or stem end of the berry; the fruit becomes soft and light-colored.

Godronia cassandrae f. sp. **vaccinii**. On blueberry.

Guignardia

► Blotch.

Botryosphaeria vaccinii (formerly *Guignardia vaccinii*). **Cranberry Early Rot**, **Scald**, **Blast**, general on cranberry and sometimes on huckleberry. All aerial plant parts are attacked, but the disease is more destructive to the fruit. Young fruit may blast and shrivel, but more often rot starts as a light-colored soft spot when fruit is half grown. The berry mummifies, turns black and is covered with small pycnidia. Leaves have reddish brown spots, sometimes drop prematurely.

Figure 3.48 Black Rot of Grapes

Guignardia bidwellii. **Black Rot** of grapes, widespread, principal cause of failure of European grapes in eastern United States, causing more loss than all other grape diseases combined. All parts of the vine are attacked. On leaves, reddish brown dead spots are sprinkled with black pycnidia. Rot starts on half-grown fruit as a pale spot, soon turning brown and involving the entire berry, which shrivels into a black wrinkled mummy, dropping or remaining in the cluster (see Fig. 3.48). Some berries shatter if attacked early. Ovoid conidia and sometimes microconidia (spermatia) are formed on leaves, berries and canes. Ascospores are produced in overwintered mummied berries. Primary infection in spring comes from either spore form.
Thecaphora deformans. **Seed Smut** of lupine.
Control. If mildew is also a problem, use a fixed copper. Cultivate in early spring so as to cover old mummies with soil and so eliminate that source of inoculum.
Guignardia vaccinii (see *Botryosphaeria vaccinii*). **Cranberry Early Rot**, **Scald**, **Blast**, general on cranberry and sometimes on huckleberry.

Helicobasidium

Basidiomycetes, Septobasidiales

An exposed cottony hymenium or fruiting layer; basidia transversely septate; spores coiled like a watch spring.

Helicobasidium corticioides. **Brown Pocket Rot** on subalpine fir, in Colorado.

Helicobasidium brebissonii (Anamorph, *Rhizoctonia crocorum*). **Violet Root Rot** of potato, sweetpotato, asparagus, beet, carrot and some ornamentals – ash, catalpa, chinaberry, crocus, elm, mulberry, parthenocissus and western soapberry. The fungus invades roots from the soil, turning them reddish or violet. The disease is confined to underground parts unless continuously wet weather allows the reddish-purple mycelium to grow up the stem. Small, darker sclerotia are embedded in this purplish mat, which turns brown with age.

Helminthosporium

► Blights.

Bipolaris cactivora (formerly *Helminthosporium cactivorum*). **Stem Rot** of cacti, **Basal** or **Top Rot** of seedling cacti, which turn into a shrunken brown mummy covered with spores. Initial symptoms are yellow lesions; rotting may be complete in 2 to 4 days.

Exserohilum turcicum (formerly *Helminthosporium turcicum*). **Crown Rot** of sweet corn, **Leaf Blight**. ► Blights.

Helminthosporium cactivorum (see *Bipolaris cactivora*). **Stem Rot** of cacti, **Basal** or **Top Rot** of seedling cacti.

Helminthosporium sesami. **Stem Rot** on sesame in Texas.

Helminthosporium turcicum (see *Exserohilum turcicum*). **Crown Rot** of sweet corn, **Leaf Blight**.

Hericium

Basidiomycetes, Aphyllophorales

Fleshy, branched or unbranched, with subulate spines long and pendant; spores spherical or subspherical, staining blue with iodine. Like *Hydnum* but sporophore formed on wood, not on the ground.

Hericium erinaceus (Syn. *Hydnum erinaceus*), hedgehog fungus. **White Heart Rot**, occasional on living oak, maple and other trees. The soft white spongy rot may entirely decompose the tissue, leaving large hollows lined with yellowish mycelium. Sporophores are annual; soft, white, browning with age, globular with a hairy top and long slender teeth on the lower surface.

Grandinia (Hyphodontia)

Basidiomycetes, Aphyllophorales

Grandinia granulosa (formerly *Hyphodontia aspera*). **Root and Butt Rot** of spruce.

Hypholoma

Basidimycetes, Agaricales

Margin of cap with a curtainlike veil; stipe with incomplete or vanishing ring; spores purple.

Hypholoma sublateritium. **Root Rot** of currant.

Idriella

Deuteromycetes, Hyphomycetes

Mycelium hyaline to brown; conidophores brown, simple, nonseptate, narrowed above, with prominent spore scars; conidia (sympodulospores) lunate to falcate, with pointed ends, produced in clusters near apex of the conidiophore; aleuriospores brown, several-celled.

Idriella lunata. **Root Rot** on strawberry.

Inonotus

Inonotus tomentosus (Syn. **Polyporus tomentosa**). **Root Rot** of spruce.

Irpex

Basidiomycetes, Aphyllophorales

Resupinate, effused-reflexed, or shelf-like; younger parts of hymenophore are poroid; with increasing age produce flattened teeth.

Irpex lacteus. **Wood Rot** and **Decline** of apple.

Gliocladium (Isaria)

Deuteromycetes, Hyphomycetes

Conidiophores equally distributed on a synnema, erect fascicle of hyphae; conidia hyaline, one-celled, ovoid; some species in insects.

Gliocladium roseum (formerly *Isaria clonostachoides*). **Isaria Rot** of tomato. Fruits are partly covered with cottony mycelium, white turning pink or orange and becoming granular, but rot remaining firm. Reported from around Washington, D.C.
Isaria clonostachoides (see *Gliocladium roseum*). **Isaria Rot** of tomato.

Kluyveromyces

Ascomycetes, Saccharomycetaceae

Kluyveromyces marxianus var. **marxianus**. **Soft Rot** of onion caused by a true yeast on bulbs.

Lasiodiplodia

Deuteromycetes, Coelomycetes

Lasiodiplodia theobromae. **Collar Rot** on peanut.

Lentinus

Basidiomycetes, Agaricales

Gills are notched or serrate at edge, decurrent, stipe often lateral or lacking cap, tough-fleshy to leathery; spores white.

Lentinus lepideus (see *Neolentinus lepideus*). **Scaly Cap**, causing a brown cubial rot of coniferous wood and sometimes decaying heartwood of living pines.

Lentinus tigrinus. **Sapwood Rot**, white mottled butt rot of living hardwoods, commonly associated with fire scars and one of the most important decay fungi in the Mississippi Delta. Fruiting body is white with cap depressed in center, more or less covered with blackish brown hairy scales, rarely developing on living trees.

Neolentinus lepideus (formerly *Lentinus lepideus*). **Scaly Cap**, causing a brown cubial rot of coniferous wood and sometimes decaying heartwood of living pines.

Lenzites

Basidiomycetes, Aphyllophorales

Pores elongated radially to resemble gills; pileus shelflike; woolly and zonate above.

Gloeophyllum sepiarium (formerly *Lenzites saepiaria*). **Timber Rot**, **Brown Pocket Rot**, usually of dead sapwood, occasionally a heart rot, rarely on living trees. This is the common destroyer of coniferous slash; it is found on telephone poles and other timber. Fruiting bodies are long narrow shelves coming from cracks, the upper surface a yellow red to dark reddish brown.

Lenzites betulina. **Heart Rot** of birch and cypress.

Lenzites saepiaria (see *Gloeophyllum sepiarum*). **Timber Rot**, **Brown Pocket Rot**, usually of dead sapwood, occasionally a heart rot, rarely on living trees.

Leptosphaeria

► Blights.

Leptosphaeria korrae. **Root and Crown Rot** of turf grasses (necrotic ring spot).

Macrophoma

► Cankers.

Macrophoma sp. **Fruit Rot** of grape.

Macrophomina

Deuteromycetes, Coelomycetes

Spores hyaline, one-celled, in pycnidia.

Macrophomina phaseolina (Anamorph, *Sclerotium* or *Rhizoctonia bataticola*). **Charcoal Rot**, **Ashy Stem Blight**, on many plants in warm climates and sometimes in temperate zones. The name for the sterile stage comes from sweetpotato, and the term charcoal rot is used because the interior of the potato becomes jet black.

The fungus lives in the soil, is particularly prevalent in warm soils and attacks roots and stems of a varied list of hosts, including bean, lima bean, soybean, beet, corn, cowpea, cabbage, eggplant, garlic, gourds, pepper, strawberry and watermelon; also chrysanthemum, dahlia, garden mallow, mountain-laurel, marigold and zinnia. In most cases the pycnidial stage is not formed. The mycelium spreads through the soil, and very small black sclerotia are formed in great abundance on or in lower stems and roots. On beans, black sunken cankers appear just below the cotylendonary node, and the lesion may extend up the stem, ashy gray in the center. Stems may break over, or the growing point may be killed. In sweetpotatoes the disease is a storage rot, the tissue becoming a dark red-brown with the outer zone black from the formation of myriads of sclerotia. The decay is spongy, then hard, mummified. The fungus is spread in irrigation water, crop debris, imported soil and on seed.

Control. Use bean seed grown in western disease-free regions. Keep plants growing vigorously with proper food and water; practice general sanitation.

Macrophomina phaseolina. **Charcoal Rot** on soybean, sunflower, *Amaranthus, Euphorbia* spp., *Ipomea, Sonchus* and *Tidestrominia*; root rot on caper spurge.

Magnaporthe

Ascomycetes, Diaporthales

This is characterized by the production of perithecial ascocarps produced in a stroma of fungal and substrate tissues or directly from somatic hyphae on the substrate.
Magnaporthe poae. Summer patch and large brown patch on grass.

Melanconium

► Leaf Spots.

Greeneria uvicola (formerly *Melanconium fuligineum*). **Bitter Rot** of grapes, widespread but especially serious on Muscadine grapes in Georgia. Decayed berry pulp has a bitter taste; up to 30% of fruit is reduced to dry, hollow shells. Spray with bordeaux mixture three times at 14-day intervals beginning after fruit is set. The later sprays for black rot should control bitter rot.
Melanconium fuligineum (see *Greeneria uvicola*). **Bitter Rot** of grapes, widespread but especially serious on Muscadine grapes in Georgia.

Mycocentrospora

Deuteromycetes, Hyphomycetes

Mycocentrospora acerina. **Dry Rot** of carrot.

Monilinia

► Blights.

Monilinia fructicola (Syn. *Sclerotinia fructicola*). **Brown Rot** of stone fruits, blossom blight, general on peach, plum and cherry, also on apricot, almond, beach, plum, Japanese quince, and, rarely, apple and pear. The fungus is distinct from the species in Europe (*Sclerotinia fructigena*) causing brown rot of stone fruits and also a serious apple rot. In the United States, brown rot is our most destructive stone-fruit disease, causing an annual peach loss of over $5 million. *Monilina fructicola* is the usual causative agent east of the Rocky Mountains; *M. laxa* causes a similar rot and blossom blight on the Pacific Coast. See also ► Blights.

Flowers turn brown prematurely, rot in moist weather; the calyx cup is blackened, and the discoloration may extend down into the pedicels. Infrequently there is a leaf and twig blight; cankers are formed on the larger limbs, with exudation of gum. The fruit rot is the familiar stage seen in any backyard with a fruit tree and usually in baskets of peaches, plums or cherries purchased for preserving and held over to the next day. The rot starts as a small, circular brown spot but spreads rapidly to take in the entire fruit, with the rotted surface covered with gray to light brown spore tufts or cusions (sporodochia), sometimes in concentric rings (see Fig. 3.49). Conidia are formed in chains on the sporodochia. The fruit finally shrinks and mummifies and either falls to the ground or remains clinging to the tree.

The fungus and decayed tissue together form a stroma that acts as a sclerotium; in spring, if the mummy has been kept moist and partially or wholly covered with soil, cup-shaped brown apothecia are produced. Primary infection is from ascospores, forcibly ejected and carried up to blossoms by air currents or from a new crop of conidia formed on mummies hanging on trees. Secondary infection is from conidia wind-borne from blossom to blossom and later from fruit to fruit. Entrance is often through wounds made by the plum curculio, oriental fruit moth and other insects. Rotting and conidial production continue after picking.

The rot is favored by wet weather, conidia germinating only in a film of water. Acid soil is said to increase apothecial production from mummies on the ground. In a normal season reduction from blossom blight is not important because some thinning is advantageous; but if blossom blight is not prevented, inoculum is provided for the fruit rot that causes such enormous losses.

Control. Sanitary measures are important. In the small garden rake up and burn or bury deeply the fallen mummies; pick mummies from trees; cut out twigs showing gum; in summer remove infected fruit before conidia form. Standard control has been wettable sulfur sprays or sulfur dust, applied: every 3 or 4 days during bloom to control blossom blight; when shucks are falling; 2 or 3 weeks after shuck fall; and 2 to 4 weeks before fruit ripens. In some instances the newer organic fungicides are preferred to sulfur, and sometimes they are used with it. Control of the plum curculio is very important. For one or two trees in a home garden one of the all-purpose fruit sprays or dusts now available under various trade names may be satisfactory. Consult your county agent for the schedule right for your locality.

Monilinia laxa (Syn. *Sclerotinia laxa*). **Brown Rot**, green and ripe fruit rot, blossom blight, on almond, apple, apricot, cherry, peach, plum, pear, nec-

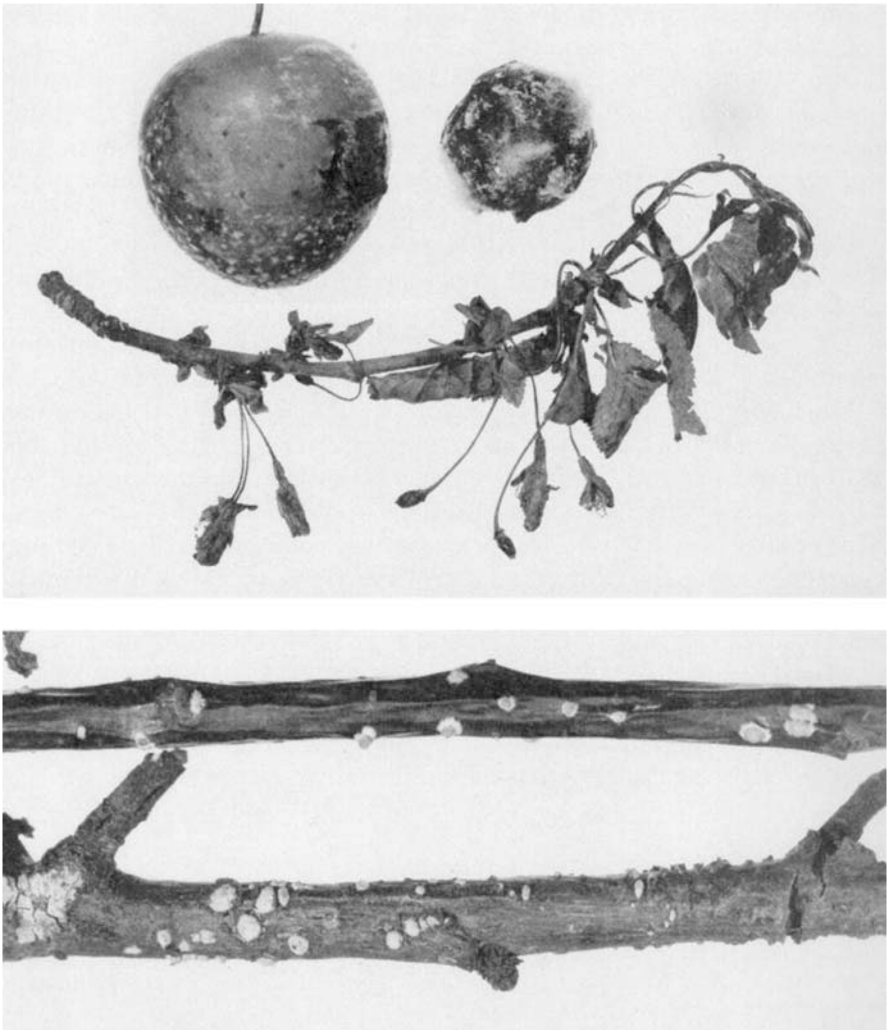


Figure 3.49 Brown Rot of Plums

tarine, quince and Japanese quince in Washington, Oregon and California; also reported from Wisconsin and Michigan. Although this disease is similar to that caused by *M. fructicola*, the blossom and twig blight phase is more important than the brown rot. Sulfur, which can be used in later sprays for most stone fruits, may injure apricots.

Monilinia oxycocci (Syn. *Sclerotinia oxycocci*). **Cranberry Hard Rot**, **Tip Blight** in Pacific Northwest and Wisconsin. Young growing tips wilt and dry just before blossoming; grayish spores tufts are formed on tips. Fruit is attacked through blossoms or wounds. The berries are yellowish white, firm, leathery, cottony inside, turning dark and mummifying late in the season. The disease is too erratic to justify cost of regular spraying; clean harvest will prevent overwintering.

Monilinia urnula (Syn. *Sclerotinia vaccinii-corymbosi*). **Blueberry Brown Rot**, **Mummy Berry**, **Twig Blight** of high bush blueberry, similar to hard rot of cranberry. Varieties differ in susceptibility, with June and Rancocas often showing severe primary infection.

Monilochaetes

Deuteromycetes, Hyphomycetes

Conidiophores dark, erect, slender, usually simple; septate; conidia hyaline or becoming pigmented in age, borne singly at apex or produced in chains under conditions of high humidity.

Monilochaetes infuscans. **Root Rot** of weed species of genus *Ipomoea*.

Monosporascus

Ascomycetes, Sordariales

Monosporascus cannonballus. **Root Rot** on cantaloupe and watermelon.

Mucor

Zygomycetes, Mucorales

Mycelium profusely developed. Sporangiophores erect, simple or branched, all branches terminated by sporangia which are globose to pyriform with a columella and thin wall; gametangia essentially alike, suspensors without definite outgrowths; hyaline chlamydospores sometimes formed.

Mucor mucedo. **Postharvest Rot** of tomato.

Mucor piriformis. **Postharvest Rot** of tomato. **Fruit Rot** of cherry.

Mucor racemosus. **Storage Rot** of sweetpotato, occasional after chilling; **Fruit Rot** of citrus. Control with low temperatures and dry atmosphere in the storage house.

Mycoleptodiscus

Mycoleptodiscus terrestris. **Root and Stem Rot** of soybean and birdsfoot trefoil.

Myrothecium

► Leaf Spots.

Myrothecium roridum. **Ring Rot** of tomato, **Crown Rot** of snapdragon and pansy. Crowns of greenhouse snapdragons appear water-soaked, then covered with a thin white mycelium and numerous black sporodochia. Irregular brown spots on tomato fruits are surrounded by slight depressions. Also causes root rot of red clover and alfalfa.
Myrothecium sp. On Bells of Ireland, causing crown necrosis. Stems are girdled at ground level; tops wilt; basal branches die.

Nematospora

Ascomycetes, Saccharomycetales

This is a yeast or budding fungus, following after insect injury; asci, with 8 to 16 spores, derived directly from vegetative mycelial cells; spores elongate, fusiform to needle-shaped, flagellate.

Nematospora coryli. **Yeast Spot** of soybean, **Dry Rot** of pomegranate, citrus, **Pod Spot** of pepper, bean and soybean, **Cloudy Spot** of tomato, **Kernel Spot** of pecan. The yeast is almost always associated with plant bug injury. The western leaf-footed plant bug carries the fungus from pomegranate to citrus. On pomegranates depressed light spots in flesh around seeds are followed by general browning and collapse. In citrus, the juice sacs just inside the rind dry out with a brownish to reddish stain. Cloudy spot on tomato fruit is associated with pumpkin bugs and leaf-footed plant bugs. Brown areas are formed on pecan kernels.
Nematospora phaseoli. **Yeast Spot** of lima bean, a seed disease, destructive from Maryland southward. Infection follows puncture of pods by the southern green stinkbug and possibly other insects. The seed lesions are dark brown, sunken, wrinkled.

Neurospora

Ascomycetes, Sordariales

Perithecia flask-shaped, membranous; ascospores dark, one-celled with gelatinous coating; conidial stage monilioid

Neurospora sitophila. **Ripe Rot** of pear. The fungus is the same one causing pink bakery mold on bread. There is a luxuriant pink growth over fruit; conidia are formed in chains.

Nigrospora

Deuteromycetes, Hyphomycetes

All hyphae more or less creeping, hyaline; conidiophores short, dark, cells somewhat inflated; conidia black, one-celled, situated on a flattened, hyaline vesicle at top of the conidiophore.

Nigrospora oryzae. **Ripe Fruit Rot** of tomato, **Nigrospora Cob Rot** of corn. Corn cobs are shredded, with the pith completely disintegrated; kernels are filled with masses of black spores. Corn on poor soil is more susceptible; stalks break over at any point. Rapid drying checks infection of seed corn.

Olpidium

Chytridiomycetes, Spizellomycetales

Endobiotic, living in host cells or tissues, living or dead.

Olpidium brassicae. Sometimes found in outer cells of rootlets of cabbage and other crucifers, tomato, lettuce and other plants, producing zoosporangia and resting spores in the cells. The effect on the host is usually merely a slight unthriftiness. Olpidium has been found associated with a disease of lettuce, Big Vein, now thought due to a virus.

Omphalia

Basidomycetes, Agaricales

Gills decurrent, cap sunken in center, somewhat funnel-shaped; central cartilaginous stem; spores white.

Marasmiellus pigmentatus (formerly *Omphalia pigmentata*). **Omphalia tralucida**. **Decline Disease** of date palms. Growth is retarded; roots decay; leaves die prematurely; fruit is worthless. Deglet Noor variety is most susceptible. Select thrifty offshoots from healthy plants for new date gardens. Soil can be treated with carbon disulfide, as for Armillaria rot.

Omphalia pigmentata (**Omphalia tralucida**) (see *Marasmiellus pigmentatus*). **Decline Disease** of date palms.

Oospora (Geotrichum)

Deuteromycetes, Hyphomycetes

Slender branched or unbranched mycelium breaking up into ellipsoidal or spherical hyaline or light-colored conidia called "oidia."

Geotrichum citriaurantii (formerly *Oospora citri-aurantii*). **Sour Rot** of citrus. This is a soft, putrid slimy rot of fruit, mostly of stored lemons, where it is spread by contact. The mycelium forms a thin, compact, somewhat wrinkled layer over the surface. Fruitflies help to spread the spores. Fruit should be stored as short a time as possible and frequent inspections made during storage.

Geotrichum candidum (formerly *Oospora lactis*). **Sour Rot**, **Watery Fruit Rot** of tomato, common in transit and market, especially on fruit from the South. There is a velvety or granular coating over the surface or a fluffy growth along the margin of cracks, and a disagreeable odor and flavor. The rot is common on ripe fruit touching the ground, occasional on green fruit. The fungus is a weak parasite, entering through wounds.

Oospora citri-aurantii (see *Geotrichum citriaurantii*). **Sour Rot** of citrus.

Oospora lacti (see *Geotrichum candidum*). **Sour Rot**, **Watery Fruit Rot** of tomato, common in transit and market, especially on fruit from the South.

Ophiosphaerella

Deuteromycetes, Hyphomycetes

Ophiosphaerella sp. **Large Brown Patch Rot** on bermudagrass and creeping bentgrass.

Paecilomyces

Deuteromycetes, Hyphomycetes

Conidiophores and branches more divergent than in *Penicilllium*; conidia (phialospores) in dry basipetal chains, one-celled, ovoid to fusoid, hyaline.

Paecilomyces buxi (see *Sesquicillium buxi*). **Root Rot** and **Decline** on boxwood.
Sesquicillium buxi (formerly *Paecilomyces buxi*). **Root Rot** and **Decline** on boxwood.

Pellicularia

► Blights.

Thanatephorus cucumeris (Syn. *Pellicularia filamentosa*) (considered by some *Botryobasidium*). **Rhizoctoniose**, **Black Scurf** of potatoes, stem canker and soil rot of beans (see under Blights for Web Blight of beans and other plants); Rhizoctonia Dry Rot Canker of Beets, Crown and Crater Rot of Carrots; Rhizoctonia Disease of Celery, Crucifers, Cucurbits; Bottom Rot of Lettuce; Damping-Off of Pepper and Eggplant; Root Rot of Onion; Root and Basal Stem Rot of Pea; Crown Rot of Rhubarb. The sterile state of this fungus, *Rhizoctonia solani*, was first named in 1858 in a German textbook and is still the most familiar term for a fungus with many pathogenic strains causing many types of diseases.
Any cook has seen signs of the pathogen on potato tubers – small brown to black hard flecks, sclerotia, on the skin. They look like particles of dirt but do not scrub off when potatoes are washed. There may be only one or two sclerotia, or they may nearly cover the whole surface of the tuber. When such potatoes are planted, the growing point may be killed. Some sprouts renew growth after being girdled, which may be repeated until they die. Larger plants have stems decayed just below the soil line, interrupting the downward transfer of food and resulting in a cluster of green or reddish aerial tubers. Roots may be killed back extensively. Most of the tubers are small, often with a brown jelly rot at the stem end.
Under moist conditions a white cobwebby weft of mycelium is formed at the base of potato stems, and the basidial stage is produced as a powdery crust on this weft. The fungus winters as mycelium or sclerotia in soil or tubers. The

mycelium can grow saprophytically long distances in the soil independent of any plant. Infection is favored by cool temperatures; the disease is most serious in wet seasons on heavy soils. The average yearly loss for the country is about 10 million bushels, 2 to 3%, but individual losses may be from 5 to 50%. For control use healthy tubers for seed.

Thanatephorus cucumeris (Syn. *Pellicularia filamentosa* (Anamorph, *Rhizoctonia solani*)). **Brown Patch** of turf, **Root and Leaf Rot** of lawn grasses, wheat grass, bentgrass, fescues, ryegrass, Kentucky bluegrass (infrequently on Canada bluegrass), St. Augustine grass, and Bermuda grass. Brown or blackish patches on the turf resemble sunscald or chinch bug injury. The areas are roughly circular, from an inch to 3 feet across, sometimes up to 20 feet. The fungus works outward with a "smoke ring" of grayish black mycelium at the advancing margin. The leaves are first water-soaked, black, then collapsed, dry and light brown, but the roots are seldom killed. The disease develops most rapidly during warm humid periods and with an excess of nitrogen.

Thanatephorus cucumeris (Syn. *Pellicularia filamentosa* (Anamorph, *Rhizoctonia solani*)). **Root and Stem Rot**, **Damping-Off** of ornamentals. In wet weather cobwebby mycelium develops on lower portions of stems; the lower leaves rot and upper portions of plants wilt and die. Seedlings and older plants so rotted include *Aconitum*, abelia, *Achillea, Ageratum*, aster, artichoke, begonia, calendula, campanula, carnation, endive, dahlia, delphinium, geranium, iris, lettuce, lupine, orchids, platycodon, poinsettia, salsify, sunflower and tulip. For control avoid excessive use of manure.

Penicillium

► Cankers.

Various species cause blue, green, occasionally pink molds, including the common blue-green mold on jellies. Some produce antibiotics, *Penicillium notatum* being the one used for production of penicillin.

Gliocladium roseum (formerly *Penicillium roseum*). **Fruit Rot** of citrus and of dates. A pink mold, found on lemons but not oranges.

Gliocladium vermoeseni (formerly ***Penicillium vermoeseni***). **Bud Rot** of palms. The terminal bud is killed and base of leaf stalks rotted. Affected trees of very susceptible *Washingtonia filifera* should be replaced with resistant *Washingtonia robusta*, Mexican fan palm. Also ► Cankers.

Penicillium aurantiogriseum. **Crown Rot** of asparagus, a seedling disease recently prevalent in Washington, following freezing injury. Bright blue spore masses appear on diseased crowns. Protect seedlings for winter by slight hilling in fall; avoid mechanical injury in harvesting; prevent drying out of crowns between digging and replanting.

Penicillium digitatum. **Green Mold** of citrus fruit, **Clove Rot** of garlic. On lemons and other citrus, olive-green powdery spore masses, forming a dust cloud when disturbed, cover fruit except for a band of white mycelium outside the green area. Garlic plants are yellow and stunted. Avoid injury in harvesting and packing. Commercial growers use chemicals in the wash water to prevent decay.

Penicillium expansum. **Blue Mold Rot** of many fruits; **Soft Rot** of apple, pear, avocado, pomegranate, Japanese persimmon, quince and feijoa. The decay on avocados is slow, and often the affected portions can be trimmed off. This fungus causes 80 to 90% of the decay of storage apples. The rotted portions are light-colored, soft, watery, with a disagreeable moldy taste and odor. A few rotted apples spoil all the others in a container. Use great care in harvesting and grading to avoid wounds; keep temperature as low as possible.

Penicillium gladioli. **Blue Mold Rot**, **Penicillium Dry Rot** of gladiolus, also found in imported bulbs – scilla, tritonia (montbretia). This is a storage rot. Light to dark brown sunken lesions appear on any part of corms with border of the decayed area water-soaked and greenish. Small grayish sclerotia are formed, and under moist conditions masses of blue mold. Dry rapidly after harvest, 80°F for 10 to 14 days, then store at low temperature; avoid wounds and bruises; sort before planting.

Penicillium italicum. **Blue Contact Mold** of citrus, **Fruit Rot**. The mold is blue in the older portion but powdery white at margins. It spreads readily from fruit to fruit by contact, through uninjured skin.

Penicillium roseum (see *Gliocladium roseum*). **Fruit Rot** of citrus and of dates. A pink mold, found on lemons but not oranges.

Penicillium vermoeseni (see *Gliocladium vermoeseni*). **Bud Rot** of palms.

Peniophora

Basidiomycetes, Aphyllophorales

Like *Corticium* but with cystidia.

Chaetoderma luna (formerly *Peniophora luna*). **Brown Rot** in lodgepole pine, Rocky Mountain area.
Peniophora luna (see *Chaetoderma luna*). **Brown Rot** in lodgepole pine, Rocky Mountain area.

Pestalotia

► Blights.

Pestalotia longisetula. **Root, Stolon, and Petiole Rot** on strawberry.

Phaeoacromonium

► Blights.

Phaeoacremonium aleophilum. **Decline** of grape.
Phaeoacremonium chlamydosporum. **Decline** of grape.
Phaeoacremonium inflatipes. **Decline** of grape.

Phialophora

Deuteromycetes, Hyphomycetes

Conidiophores dark, short, single or clustered; phialides broader near middle, tapering toward ends, producing conidia endogenously, spores subhyaline to dark, one-celled.

Phialophora malorum. **Storage Rot** of apples.

Phlebia

Basidiomycetes, Aphyllophorales

Basidiocarp effuse, typically monomitic; spores even in general outline, hyaline or pale in color, typically nonamyloid.

Phlebia chrysocrea. **Heart Rot** on oak.

Pholiota

Basidomycetes, Agaricales

Spores ochre yellow to rusty brown; gills attached to stipe, which has an annulus but no cup at the base.
Pholiota adiposa. **Brown Mottled Heart Rot** of maple and other living hardwoods – basswood, birches, poplars and more rarely conifers. The wood has brown mottled streaks. The sporophores are formed in clusters on trunks and stumps – m ushrooms with yellow central stems and caps, sticky yellow slightly scaly upper surface, yellow to brown gills.

Phoma

► Blackleg.

Phoma apiicola. **Phoma Root Rot** of celery, occasionally serious, especially in Golden Self Blanching, also on carrot, parsnip, parsley and caraway. The disease appears first in the seedbed, a black rot of the crown or base of leafstalks. Plants are stunted, outer leaves or entire plant killed, falling over as roots rot off. Spores are produced in tendrils from black pycnidia and spread in rains and irrigation water. Use clean seed, grown in California, where the disease is rare; sterilize seedbed soil or use a fresh location.
Phoma betae (Teleomorph, *Pleospora betae*). **Phoma Rot** of beets, causing black root of seedlings, necrotic streaks on seedstalks, brown spots on old leaves and rot of fleshy roots. The fungus is seed-borne and winters in roots carried over for seed production and in debris. Crop rotation is essential.
Phoma destructiva. **Phoma Rot** of tomato, pepper, nearly general, especially in the South, but not in North Central States. Small, irregular dark spots appear on leaves in great numbers; zonate markings are similar to those of early blight. Severely infected leaves turn yellow, wither. Fruit spots in field are small, 1/8 inch, slightly depressed, with numerous tiny black pycnidia. After harvest, spots enlarge to 1/2 to 1 1/2 inches and become black, leathery, with minute pustules. The fungus winters in decaying refuse in soil; seedbed infection is common, and the disease reaches the field via infected seedlings. Masses of spores produced on leaves are washed to fruits by rain or spread by workers and are distributed during harvesting and packing.

Control. Locate seedbeds away from land that has previously grown tomatoes; spray as for early blight; do not harvest when wet.
Phoma macdonaldii (Teleomorph, *Leptosphaeria lindquistii*). **Stem Rot** on sunflower.
Phoma terrestris on sweet corn.
Phoma sp. **Crown and Root Rot** on bugleweed.

Phomopsis

► Blights.

Phomopsis amygdali. **Fruit Rot** on almond.
Phomopsis mali. **Fruit and Core Rot** (Postharvest) on apple.
Phomopsis vaccinii. **Fruit Rot** on blueberry.
Phomopsis sp. **Fruit Rot** on peach.

Phymatotrichopsis (Phymatotrichum)

Deuteromycetes, Hypohomycetes

Conidiophores stout with inflated tips bearing loose heads of conidia; spores hyaline; one-celled, produced on surface of soil.

Phymatotrichopsis omnivors (formerly *Phymatotrichum omnivorum*). **Texas Root Rot**, **Phymatotrichum Root Rot**, **Cotton Root Rot**. This is the most destructive plant disease in Texas, a limiting factor in gardening and crop production. It occurs in the Red River counties of Oklahoma, the southwestern half of Arizona, the southeastern edge of Nevada and California, the southeastern corner of Arkansas and Utah, the northwestern corner of Louisiana and in most of Texas except the Panhandle.
The list of susceptible plants flowers, vegetables, fruits, field crops and trees – is much longer than that of plants resistant to this omnivorous fungus, so aptly named. At least 1700 plant species are attacked, more than by any other known pathogen. Because of the wide host range and destructiveness, the economic losses are enormous, \$100 million a year in Texas alone, with perhaps \$50 million in adjacent states.
Crops that either are resistant or escape the disease are the cereals and grasses, annuals grown in winter only, and sweet alyssum, amaranth, sweet basil,

beauty-berry, bee-balm, collinsia, diosma, calceolaria, calla lily, California-poppy, candytuft, canna, chicory, cranberry, cucumber, currant, cyclamen, daffodil, dahoon, deutzia, dill, fenner, fern, staghorn, foxglove, freesia, goldentuft, mustang grape, gypsophila, hackberry, hoarhound, hyacinth, iris, lily, nigella, marsh-marigold, mignonette, mints, mimulus, muskmelon, mustard, nasturtium, oak, osage-orange, oxalis, Indian paint-brush, palms, pansy, petunia, phlox, Chinese pink, pitcher-plant, pomegranate, poppy, portulaca, primrose, pumpkin, red-cedar, sage, scarlet-brush, snapdragon, snowdrop, stock, strawberry, strawflower, tuberose, valerian, verbena, violet, wallflower, wandering jew, water cress, watermelon, yaupon, yucca and zinnia.

Phymatotrichum root rot occurs from July until frost. It kills plants in more or less circular spots, ranging from a few yards to an acre or more. Death may come within a few days of first wilt symptoms, and just preceding the wilt plants actually run a fever, with a higher than normal temperature. If plants next to the wilted ones are pulled out, these apparently healthy plants will often be found to be covered with yellow to buff mats of mycelium, and under moist conditions spore mats appear on the surface of the soil around diseased plants. Such mats are 2 to 12 inches in diameter, first snow white and cottony, later tan and powdery from spores produced in quantities. The fungus spreads through the soil by means of rhizomorphs, smooth, dark brown strands. The rate of spread may be 2 to 8 feet a month in an alfalfa field, 5 to 30 feet a season in a cotton field, or around fruit trees.

Sclerotia are formed along the mycelial strands. They are small, roundish, light at first, then dark and warty. The fungus winters either as sclerotia in soil, persisting several years in the absence of live hosts, or as dormant mycelium in living roots. The disease is most common and severe on heavy, alkaline soils. Abundant organic material reduces rot by favoring antagonistic soil saprophytes.

Control. In ornamental plantings replace diseased plants with some of those given in the resistant list. Monocotyledons are generally resistant. In locating new orchards, make sure that root rot has not been present previously by growing an indicator crop of cotton for a year. Grow immune crops in rotation with susceptible crops, and grow susceptible annuals in winter rather than summer. Try heavy manuring.

Ammonium sulfate can sometimes save a valuable ornamental tree or shrubs already infected with root rot. Prune back the top, make a circular ridge about the plant at the edge of the branch spread, and work ammonium sulfate into the soil within the ridge then fill the basin with water to a depth of 4 inches. The chemical treatment and watering is repeated in 5 to 10 days, then no more chemical the same season. Follow through with frequent watering.

Phymatotrichum omnivorum (see *Phymatotrichopsis omnivors*). **Texas Root Rot**, **Phymatotrichum Root Rot**, **Cotton Root Rot**.

Physalospora

► Cankers.

Botryosphaeria stevensii (formerly *Physalospora mutila*). **Black Rot** of apple, in the West, similar to disease by *P. obtusa* in the East.

Botryosphaeria obtusa (formerly *Physalospora obtusa*). **Black Rot** of apple, **New York Apple Tree Canker**, **Frog-Eye Leaf Spot**, general on apple and crabapple, from Atlantic Coast to the Great Plains; also widespread on pear, mountain-ash, peach, quince, currant and various woody species. The fungus, in its anamorph state (*Sphaeropsis malorum*), was first reported as causing apple rot in 1879.

The lesions start as small brown spots, frequently at a wormhole, but they darken and turn black as they expand. There is usually one lesion to an apple, often at the calyx end, with concentric zones of black and brown, and minute black pycnidia. The rot eventually takes in the whole fruit, which is shriveled and wrinkled and finally mummifies. The pycnidia are black, carbonaceous, and may contrain three types of spores – large one-celled brown spores, large hyaline spores, and two-celled colored spores. Perithecia, sometimes formed in cankers or on twigs, apparently play little part in the life history, the fungus wintering as dormant mycelium or in the pycnidial state. Conidia, entering through wounds, start primary infection in spring on leaves with the small “frog-eye” leaf spots.

Control. Use the same spray schedule as for apple scab, starting with the petal-fall application. Clean up mummied apples; avoid bruising; cut out cankers.

Botryosphaeria rhodina (formerly *Physalospora rhodina*). **Diplodia Rot** of citrus, fig, rubber-tree and pear, possibly apple. The conidial stage is a *Diplodia*, probably *D. natalensis*, with dark, two-celled spores.

Physalospora mutila (see *Botryosphaeria stevensii*). **Black Rot** of apple, in the West, similar to disease by *P. obtusa* in the East.

Physalospora obtusa (see *Botryosphaeria obtusa*). **Black Rot** of apple, **New York Apple Tree Canker**, **Frog-Eye Leaf Spot**, general on apple and crabapple, from Atlantic Coast to the Great Plains; also widespread on pear, mountain-ash, peach, quince, currant and various woody species.

Physalospora rhodina (see *Botryosphaeria rhodina*). **Diplodia Rot** of citrus, fig, rubber-tree and pear, possibly apple.

Phytophthora

► Blights.

Phytophthora cactorum. **Stem Rot**, **Foot Rot** of lily, *Photinia*, tulip, *Hydrastis*, blue laceflower, baby's breath, *Centaurea*, peony, clarkia, rhubarb and tomato; leather rot of strawberries; collar rot of dogwood, walnut, apple and pear; crown rot of Euonymus and strawberry; root rot of boxwood and vinca, and crown rot of peach and Cannan fir; kernel and shuck rot of pecan. With foot rot, lilies suddenly fall over, wilt and die; the lower part of the stem is shrunken. Plant only healthy bulbs and where the disease has not occurred previously.

Strawberry leather rot occurs when berries come in contact with soil, starting with a brown rotted area on green fruit and a discoloration of vascular bundles. Ripe fruit has a bitter taste. Crown rot of rhubarb starts with slightly sunken lesions at base of petiole, which enlarge until the entire leaf collapses. Spraying crowns with bordeaux mixture is helpful. Start new beds with healthy plants. Collar rot on English walnut is a bark disease starting below the ground with irregular dark brown or black cankers and soft, spongy areas at the crown, a black fluid in cambial cavities. Trees are stunted, with sparse yellow-green top growth. There may be an unusually heavy crop of nuts, but the tree dies the next season. Grow walnuts grafted on Persian or Paradox rootstocks. See under Cankers for symptoms on apple and dogwood.

Stem rot and wilt of snapdragon starts with water-soaked lesions on the stem; these turn yellow, brown, enlarge to girdle the stem; plant wilts. Sterilize soil before planting.

Phytophthora capsici. One of the species causing buckeye rot of tomato. See under Blights for pepper rot and blight.

Phytophthora cinnamomi. **Avocado Root Rot**, **Pine Little Leaf**, **Collar Rot** of hardwoods and conifers, seedling root rot, on more than 100 hosts, including firs, cedars, cypress, juniper, Japanese umbrella tree, larch, pine, spruce, arborvitae, heaths, heather, azalea, Heuchera, cranberry, highbrush blueberry, rhododendron, camellia, birch, western swordfern, manzanita, walnut, oak, locust, yew, venus-flytrap and gold-dust plant. In conifers root rot is dry with resin flow; needles gradually lose color. Infected tissue of hardwoods turns reddish brown except in black walnut, where it is black; seedlings die. The disease is aggravated in pine by poor aeration and low fertility.

Root rot is the most serious avocado disease in California, present also in Florida and Texas. It occurs on soils with poor drainage, excess moisture being necessary. As the roots rot, leaves become light-colored and wilt even if soil is moist; trees decline over a period of years. The fungus can be spread with seed if fruit is allowed to lie on the ground. Treat suspected seed with hot water, 120° to 125°F for 30 minutes; use nursery stock grown in fumigated soil; prevent movement of soil water from infested areas; plant on well-drained soil; water trees individually to avoid excess moisture.

Phytophthora citricola. **Root Rot** of pine, hemlock and Fraser fir seedlings in Christmas tree plantings; also fruit rot of avocado.

Phytophthora citrophthora. **Root and Crown Rot** of Penstemon.

Phytophthora citrophthora. **Brown Rot**, **Gummosis**, **Foot Rot** of citrus. Masses of amber gum break out from the trunk near crown; the bark is killed above and below ground; foliage turns yellow; trees may die. The disease is prevalent where excess water stands around the tree after irrigation or where there is poor drainage. Brown rot of fruit is a decay with no visible surface mold, except in moist air, but a slightly rancid, penetrating odor. Lemons and oranges may be affected on the tree, on branches near the ground, and there is much loss in storage. The fungus lives in the soil; spores are splashed up in rainy weather and are spread in the washing tank. Lemons are most susceptible to gummosis, then lime, pumelo, grapefruit, sweet orange and finally sour and trifoliate oranges. The latter two are used as fairly resistant understocks.

Control. Plant susceptible trees high, with lateral roots barely covered; expose the root crown of infected trees with a basin 6 inches deep and 4 feet across. Once a year cover crown and lower trunk with bordeaux paste. To control fruit rot, spray ground and lower branches, up to 3 feet, with bordeaux mixture just before rains begin. If fumigation is to be practiced, substitute a copper-zinc-lime spray for the bordeaux.

Phytophthora colocasiae. **Root Rot** of ginseng.

Phytophthora cryptogea. **Collar Rot** of rhododendron, China aster, marigold, gloxinia and zinnia; root, crown, and stem rot on watercress, juniper, African daisy, chicory, beet, globe thistle, lettuce, parsley, peach, sage, spruce, and ice plant; stem rot on sunflower, pink rot of potato. Stems and roots appear water-soaked, then black from a soft rot. Sterilize soil.

Phytophthora cryptogea var. **richardiae**. **Root Rot** of calla. The feeder roots rot from tips back to rhizomes, leaving the epidermis a hollow tuber. New roots sent out from the rhizome rot in turn. Leaves turn yellow and drop, starting with outer leaves; plants do not flower, or the tips of blossoms turn brown. Rot in the rhizome is dry and spongy, not wet and slimy. Clean old rhizomes thoroughly; cut out rotted spots. Grow in sterilized pots rather than benches.

Phytophthora drechsleri. **Root Rot** on fir, basil, blackberry, columbine, juniper, sage, linden, pine, and spruce. Sometimes associated with tomato buckeye rot, basal decay of sugar beets, tuber rot of potato, root rot of safflower.

Phytophthora erythroseptica. **Pink Watery Rot** of potato, **Rot** of calla lily and golden calla, **Crown and Root Rot** of wild rice. The rot starts at stem end of potatoes; affected tissues exude water under pressure. When tubers are cut, flesh turns pink or red, then black. The fungus can exist in soil 4 years.

Phytophthora fragariae. **Strawberry Red Stele Disease**, **Brown Core Rot**, a very serious strawberry disease, first noticed in Illinois in 1930, now widespread in northern strawberry sections and in California. A strain of this pathogen causes root rot of loganberry. The fungus attacks roots only, destroying fine feeding roots first, then invading the central cylinder, stele, which turns dark red. New spring leaves on badly affected plants are small, bluish, have short petioles; large leaves from the previous season dry up; little or no fruit is produced; plants die in the first dry period or are stunted.

The fungus is most active in cold, wet soil, in rainy periods in late fall, winter, and early spring except when ground is frozen. Zoospores produced on roots are spread by water; resting spores formed in the red stele carry the pathogen in a dormant state through the heat of summer. There are at least three physiological races, and once the fungus infests a field it is worthless for strawberries for 10 years.

Control. Buy clean, certified plants. Aberdeen and Stelemaster varieties are resistant; Temple, Sparkle, Fairland, Redcrop, and Pathfinder, fairly so.

Phytophthora lateralis. **Cypress Root Rot** on Lawson cypress (*Chamaecyparis lawsoniana*) often called Port Orford cedar, and Hinoki cypress (*C. obtusa*), killing thousands of trees in Oregon nurseries and landscape plantings. It is found on juniper and azalea in North Carolina. It is also reported on mountain-laurel and *Photinia* in NC and on cypress from Washington and apparently native to the Northwest. The fungus enters through the roots and spreads to lower part of main trunk killing the tissues. Blue cypress changes to purple, green, finally tan and dies. The color changes take several months in cool, damp weather, only 2 or 3 weeks in hot, dry weather. There is no practical chemical control, and Lawson cypress seems to be incompatible with resistant rootstocks. Grow disease-free propagating stock in new soil. Avoid large plantings of Lawson cypress such as windbreaks or hedges. Remove and destroy infected plants, getting the entire root system.

Phytophthora megasperma. **Root Rot**, occasional on cabbage, cauliflower, brussel sprouts, carrot, artichoke, stock, citrus, soybean and wallflower. Diseased plants wilt suddenly; leaves turn red to purple; underground stems and roots rot. The disease is more prevalent in winter plantings in California and in low, poorly drained areas. Level ground properly before planting to avoid waterlogged spots. Root and crown rot on peach.

Phytophthora megasperma f. sp. **glycinea**. **Root and Stem Rot** on soybean.

Phytophthora nicotianae var. **nicotianae**. **Crown Rot**, **Root Rot**, and **Stem Canker** on flannel bush.

Phytophthora nicotianae var. **parasitica** Syn. *Phytophthora parasitica* (*P. terrestris*). **Brown Rot** of citrus, in Florida; **Buckeye Rot** of tomato, also on lily roselle, sempervivum, potato (tuber rot), zebra plant (stem rot), sage (root rot), and Christmas cactus (root rot). The disease appears on the lowest tomato fruits, where water stands after rains. The lesions have concentric narrow dark brown bands alternating with wide light brown bands. The decay is rapid and the internal tissue semi-watery, though the exterior is firm. Control by staking tomatoes; avoid poorly drained soil or plant on ridges. This species is often present with *P. citrophthora* in cases of citrus foot or collar rot.

Phytophthora nicotianae var. **parasitica**. **Crown Rot** on petunia and poinsettia (stem rot).

Phytophthora palmivora. **Palm Bud Rot**, **Leaf Drop**, **Wilt** of coconut, *Washingtonia*, and queen palm, root and crown rot of mango; also root rot on English ivy. The fungus is an omnivorous tropical species, presumably the one causing stem rot of dieffenbachia and peperomia. It has been prevented in nurseries by using cuttings from healthy plants in pasteurized soil.

Phytophthora parasitica var. **nicotianae** (Syn. *P. nicotianae* var. *parasitica*). **Root Rot** on pine.

Phytophthora porri. **Head Rot** on cabbage.

Phytophthora sojae (Syn. *P. megasperma* f. sp. *glycinea*). **Root and Stem Rot** of soybean, a relatively new disease reported from Illinois, Indiana, Missouri, North and South Carolina and Ohio. Serious in cool rainy weather, causing pre- and post-emergence damping-off.

Phytophthora syringae. **Root Rot** on shore juniper and Photinia.

Phytophthora torulosum. **Root Rot** and **Damping-off** on soybean.

Plectospira

Oomycetes, Saprolegniales

Sporangium with much inflated branching; swarm spores are formed in basal portion and cut out into a single row in an elongate filamentous apical portion, which acts as an exit tube. Swarm spores encyst at the mouth as in *Aphanomyces*. Oogonium terminal or intercalary, accompanied by up to 65 antheridia.

Plectospira myriandra. **Rootlet Necrosis** on tomato. The fungus is weakly parasitic on roots.

Plenodomus

Deuteromycetes, Coelomycetes

Pycnidia coriaceous or carbonaceous, more or less sclerotoid. Condiophores obsolete or none; conidia one-celled, hyaline.

Plenodomus destruens. **Foot Rot** of sweetpotato, one of the more important field diseases and sometimes a storage rot. The base of the stem turns brown from just under the soil surface to 4 or 5 inches above; leaves turn yellow and drop off; vines wilt unless adventitious roots are put out; pycnidia are numerous. The root has a firm brown rot, not affecting the whole potato but enough to make it worthless for food. The fungus winters in old plant refuse but not in soil. Use clean seed potatoes; rotate crops. This fungus also infects *Jacquemontia*.

Pleospora

► Leaf Spots.

Pleospora herbarum. **Fruit Rot** of tomato. A firm dark rot develops in fruit after picking, starting from infections through cracks near stem end of fruit. Progress is most rapid at 65° to 70°F and is checked by storage at 45°F.

Pleurotus

Basidiomycetes, Agaricales

Stipe off center or lacking; cap sometimes inverted; gills more or less fleshy and separable into two layers, edges acute; spores white.

Hypsizygus ulmarius (formerly *Pleurotus ulmarius*). **Brown Heart Rot** sapwood wound rot of elm, maple, and other living hardwoods. Rot starting in heartwood may extend into sapwood; infected wood separates along annual rings. Annual sporophores have a long excentric stalk, and white to yellow to brown smooth upper surface. They issue from crotches and pruning wounds.

Pleurotus ostreatus, oyster cap. **White Flaky Sapwood Rot** of maple and other hardwoods, sometimes on living trees. A light-colored decay is surrounded by a narrow brown zone. Fleshy annual conks are shelving, sessile, or with a short, stout excentric stalk. The upper surface is smooth, white or grayish, gills extending onto the stalk, an edible fungus. Infection is through open wounds. **Wood Rot** of grape.

Pleurotus ulmarius (see *Hypsizygus ulmarius*). **Brown Heart Rot** sapwood wound rot of elm, maple, and other living hardwoods.

Polyporus

Basidiomycetes, Aphyllophorales

Pileus tough, thick, with a stipe, or as a shelf; pores rounded, small, tubes crowded.

Dichomitus squalens (formerly *Polyporus anceps*). **Red Ray Rot** on western conifers, causing heart rot of living trees but beneficial as a cause of rapid decay of slash in forests. Fruiting bodies rarely develop on living trees.

Ganoderma lucidum (formerly *Polyporus lucidus*). **Root Rot** on redbud.

Inonotus dryadeus (formerly *Polyporus dryadeus*). **White Root Rot**, occasional in oaks and conifers in the West. Roots are killed; tree dies. Decayed wood is white to cream; bark is loosened and shredded.

Inonotus hispidus (formerly *Polyporus hispidus*). **White Spongy Heart Rot** of living trees of black ash, oak, maple and birch; does not decay dead trees. Heartwood in upper portion of trunk is reduced to soft spongy yellow or white mass. Shelf sporophores, up to 10 inches wide, have dark brown, coarse, velvety to hairy upper surface and golden brown undersurface, turning dark brown with age. They are formed at branch stubs, frost cracks, or trunk cankers.

Inonotus tomentosus (formerly *Polyporus tomentosus* var. *circinatus* Syn. *Inonotus circinatus*). **Root Rot** of sand pine.

Laetiporus sulphureus (formerly *Polyporus sulphureus* Syn. *Laetiporus sulphureus*), sulphur fungus. **Red Brown Heart Rot**, **Brown Cubical Rot** in heartwood of maple and other living hardwoods and conifers, widespread on oak, balsam, Douglas-fir and spruce. The annual, shelflike fruiting bodies are most conspicuous – soft, fleshy, moist when fresh, with bright orange-red upper surface and brilliant yellow underneath, formed in overlapping clusters. When old they are hard, brittle, dirty white (see Fig. 3.50). Infection is through dead branch stubs and wounds.

Phaeolus schweinitzii (formerly *Polyporus schweinitzii*) **Root Rot** on pine.

Phellinus gilvus (formerly *Polyporus gilvus*). **White Sapwood Rot**, prevalent on dead trees, occasional on living trees. Small, annual, yellow to red, brown leathery to corky sporophores, developed in profusion.

Pitoporus betulinus (formerly *Polyporus betulinus* Syn. *Piptoporus betulinus*). **Brown Cubical Rot** of dead or dying gray and paper birches. Conks have smooth grayish upper surface with incurved margin.

Polyporus abietinus Syn. Hirshioporus abietinus (see *Trichaptum abietinum*). **Pitted Sap Rot**, **Hollow Pocket**, **White Pocket Rot** on fir.

Polyporus anceps (see *Dichomitus squalens*). **Red Ray Rot** on western conifers.

Polyporus balsameus (see *Postia balsamea*). **Balsam Butt Rot** of living balsam fir, eastern hem lock, northern white-cedar, western red-cedar, also prevalent on dead trees.

Polyporus betulinus Syn. **Piptoporus betulinus** (see *Piptoporus betulinus*). **Brown Cubical Rot** of dead or dying gray and paper birches.

Polyporus dryadeus (see *Inonotus dryadeus*). **White Root Rot**, occasional in oaks and conifers in the West.

Figure 3.50 Shelf Fungus (*Laetiporus sulphureus*) on Oak

Polyporus gilvus (see *Phellinus gilvus*). **White Sapwood Rot**, prevalent on dead trees, occasional on living trees.

Polyporus hispidus (see *Inonotus hispidus*). **White Spongy Heart Rot** of living trees of black ash, oak, maple and birch; does not decay dead trees.

Polyporus lucidus (see *Ganoderma lucidum*). **Root Rot** on redbud.

Polyporus pargamenus. **White Pocket Rot** of dead sapwood in eastern United States but sometimes on living maple and other hardwoods.

Polyporus sulphureus Syn. **Laetiporus sulphureus** (see *Laetiporus sulphureus*), sulphur fungus. **Red Brown Heart Rot**, **Brown Cubical Rot** in heartwood of maple and other living hardwoods and conifers, widespread on oak, balsam, Douglas-fir and spruce.

Polyporus schweinitzii (see *Phaeolus schweinitzii*). **Root Rot** on pine.

Polyporus squamosus. **White Mottled Heart Rot** on maple, buckeye, birch and occasional on living trees near wounds. Conks are annual, fleshy, white to dingy yellow with a short, thick lateral stalk, upper surface with broad appressed scales, up to 18 inches wide.

Polyporus tomentosus var. **circinatus** Syn. **Inonotus circinatus** (see *Inonotus tomentosus*). **Root Rot** of sand pine.

Polyporus versicolor Syn. Coriolus versicolor (see *Trametes versicolor*), rainbow conk. **Sapwood Rot**.

Postia balsamea (formerly *Polyporus balsameus*). **Balsam Butt Rot** of living balsam fir, eastern hemlock, northern white-cedar, western red-cedar, also prevalent on dead trees. Advanced decay is brown, brittle, breaking into large cubes, easily crushed to a clay-colored powder. In living trees the rot column is usually only 3 or 4 feet from ground. Sporophores are shelving, up to 2 inches wide, with pale brown upper surface with concentric zones, white underneath.

Trametes versicolor (formerly *Polyporus versicolor* Syn. *Coriolus versicolor*), rainbow conk. **Sapwood Rot**. This is the most common fungus on hardwood slash in woods and sometimes on conifers. The rot is soft, white spongy. Heartwood of living catalpa may be decayed, the fungus entering through wounds and dead branches. The conks are thin, tough, leathery, annual, up to 2 inches wide with a hairy or velvety surface multicolored white, yellow, brown, gray, and black. The undersurface is yellow or white. This pathogen also causes wood decay and decline of apple and has been reported as *Trametes versicolor*.

Trichaptum abietinum (formerly *Polyporus abietinus* Syn. *Hirshioporus abietinus*). **Pitted Sap Rot**, **Hollow Pocket**, **White Pocket Rot** on fir. May attack dead sapwood in wounds of living trees.

Poria

Basidiomycetes, Aphyllophorales

Pileus resupinate, thin, membranous; tubes wartlike, separate.

Junghuhnia luteoalba (formerly *Poria luteoalba*). **Brown Rot** of coniferous wood.

Perenniporia subacida (formerly *Poria prunicola*). **White Rot** of cherry and other *Prunus* spp.

Phellinus laevigatus (formerly *Poria laevigata*). **Red Mottle Rot** on *Prunus* spp.

Phellinus weirii (formerly *Poria weirii*). **Douglas-Fir Root Rot**. The disease is most destructive to trees 70 to 150 years old, which are killed in groups. The fungus can persist in dead roots for a century. Less susceptible conifers should be planted with judicious cutting of infected stands.

Poria cocos (see *Wolfiporia cocos*). **Root Rot** on roots of various trees, especially pine, in southeastern United States.

Poria luteoalba (see *Junghuhnia luteoalba*). **Brown Rot** of coniferous wood.

Poria prunicola (see *Perenniporia subacida*). **White Rot** of cherry and other *Prunus* spp.

Poria laevigata (see *Phellinus laevigatus*). **Red Mottle Rot**, on *Prunus* spp.

Poria subacida. **Feather Rot**, **Spongy Root Rot**, **String Butt Rot** of living conifers and dead hardwood. Decay rarely extends more than 6 to 10 feet in the trunk. Irregular pockets run together forming masses of white fibers; annual rings separate readily. Sporophores are white to straw-colored to cinnamon-buff crusts forming sheets several feet long on underside of fallen trunks or on underside of root crotches or exposed roots of living trees.

Poria weirii (see *Phellinus weirii*). **Douglas-Fir Root Rot**.

Wolfiporia cocos (formerly *Poria cocos*). **Root Rot** on roots of various trees, especially pine, in southeastern United States. Huge sclerotia, weighing up to 2 pounds, are formed; this stage is known as *Pachyma cocos*.

Pyrenochaeta

► Blights.

Phoma terrestris (formerly *Pyrenochaeta terrestris*). **Pink Root** of onions, widespread on onions, garlic and shallot; also on grasses. Roots of affected plants shrivel and turn pink. New roots replacing the old are infected in turn; plants are stunted, bulbs small. The fungus persists indefinitely in the soil and is distributed on onion sets and transplants. Yellow Bermuda is the most resistant of commercial onion varieties. The green Beltsville Bunching onion, Nebuka strain of Welsh onion, Evergreen variety of shallot, and leaks and chives are resistant. In Arizona, Granex gives a better yield than other onions despite pink root.

Pyrenochaeta lycopersici. **Root Rot** on tomato.

Pyrenochaeta terrestris (see *Phoma terrestris*). **Pink Root** of onions, widespread on onions, garlic and shallot; also on grasses.

Pythium

Oomycetes, Peronosporales

Wall of sporangium smooth; discharging swarm spores in imperfectly formed state into thin-walled vesicle, which later ruptures to allow spores to escape. Sporangia terminal or intercalary. Species live in moist soil causing damping-off and root rots.

Pythium acanthicum; **P. myriotylum**; **P. periplocum**. Causing rot of watermelon fruit.

Pythium aphanidermatum. **Leak**, **Root Rot**. Damping-off of muskmelon, cucumber, squash, also papaya, bean, radish, spinach, sugar beet, guayule, caper spurge, and ice plant. There is a watery decay with a yellow brown liquid leaking out when fruit is pressed. Lesions are brown and wrinkled. The fungus lives in the soil; primary infection is in the field, secondary from contact in transit or storage. Sort carefully before packing. Refrigerate at 45° to 50°F in transit.

Pythium aristosporum. **Root Rot** of bean.

Pythium arrhenomanes. **Root Rot** on tomato, broadleaf signalgrass, large crabgrass, barnyardgrass, nutsedge, goosegrass, itchgrass and johnsongrass.

Pythium carolinianum. **Root and Stem Rot** of parrotfeather (*Myriophyllum*).

Pythium catenulatum. **Root Rot** of bean.

Pythium debaryanum. **Damping-Off** of seedlings. **Watery Leak** of potatoes. Leak starts as a brown discoloration around a wound and soon spreads to include the whole potato, which is soft, easily crushed, and drips a brown liquid with the slightest pressure. Entrance to the tuber is usually through harvest wounds. *Pythium* hyphae grow through the soil in great profusion and can enter seedlings through either stomata or unbroken epidermis. See Damping-Off, for rot of seedlings.

Pythium dissotocum. **Root Rot** of bean, and spinach.

Pythium irregulare. Associated with **Melon Root Rot** and **Fruit Rots** of

Figure 3.51 *Pythium* Blackleg on Geranium

other cucurbits in cool weather and **Seed Decay** of corn. **Root Rot** and **Crown Rots** of clovers and basil.

Pythium mastophorum. **Damping-off** on celery.

Pythium myriotylum. **Root Rot** on tomato.

Pythium paroecandrum. **Stem, Crown and Root Rot** on lupine.

Pythium polymastum. **Bottom Rot** and **Damping-off** on cabbage.

Pythium splendens. On Chinese evergreen, peperomia, and philodendron.

Pythium ultimum. **Fruit Rot** of muskmelon, often with luxuriant white fungus growth; **Damping-Off**, **Root Rot** of many seedlings in greenhouse and field. **Root Rot** and **Crown Rot** of clovers. **Crown Rot** of impatiens. **Root Rot** of kiwi.

Pythium uncinulatum. **Stunt and Leaf Yellowing** on lettuce.

Pythium spp. Most soils contain several species of *Pythium* ready to perform at optimum moisture and temperature. Exact determination is not always practical. Nematode wounds often dispose plants to rot. Diseases include African-violet rot, aloe root rot, black rot of orchids, begonia root rot, coleus black leg, geranium cutting rot (see Fig. 3.51), bean and parsley root rot, rhubarb crown rot, mottle necrosis of sweetpotato, and other rots. Some plants can be treated with hot water, 115°F for 30 minutes. Sterilize soil before use; avoid excessive watering. See Damping-Off, for seedling rots.

Rhizina

Ascomycetes, Pezizales

Cup-shaped apothecia with rhizoids underneath; asci operculate, opening with a lid, eight-spored; spores fusoid, spindle-shaped, paraphyses present.

Rhizina undulata. **Seedling Root Rot**, **Damping-Off**. Coniferous seedlings in the Pacific Northwest are sometimes killed in isolated circular patches 2 to 4 feet in diameter, particularly in burned areas. Infected roots are matted together with white mycelium. More or less resinous annual fructifications are formed on the ground. They are irregular, an undulating brown upper surface with narrow white margin, 2 to 3 inches across. There is no control, but the disease is minor.

Rhizoctonia

Deuteromycetes, Hyphomycetes

Sclerotial form of *Pellicularia, Corticium, Macrophomina, and Helicobasidium*. Young mycelium colorless; branches constricted at points of origin from main axis; older mycelium colored, wefts of brownish yellow to brown strands, organized into dense groups of hyphae, sclerotia, made up of short, irregular, angular or somewhat barrel-shaped cells (see Fig. 3.52).

Rhizoctonia sp. **Postharvest Decay** on leatherleaf fern.

Rhizoctonia bataticola. **Charcoal Rot**. ► *Macrophomina phaseoli*

Rhizoctonia crocorum. **Violet Root Rot**. ► *Helicobasidium purpureum*.

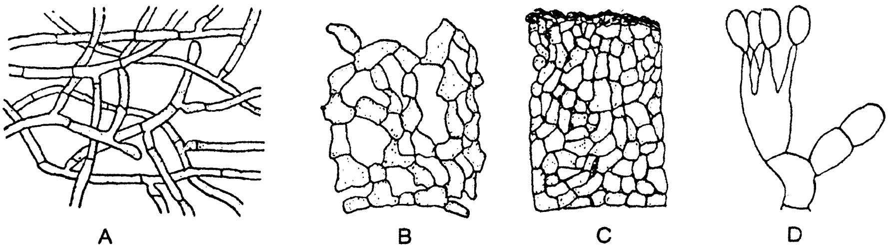


Figure 3.52 Forms of *Rhizoctonia solani*. **A** young mycelium, constricted at branches; **B** loosely formed angular to barrel-shaped colored cells; **C** section through sclerotium formed from aggregation of cells in **B**; **D** basidium and spores of *Pellicularia*, teleomorph state of *R. solani*

Rhizoctonia solani. **Black Scurf** of potatoes, **Brown Patch** of turf. ► *Pellicularia filamentosa* **Root Rot** and **Crown Rot** of clovers..

Rhizoctonia solani. **Root and Stem Rot** of poinsettia and other ornamental plants, including basil, begonia, camellia, calla, carnation, chrysanthemum, coleus, cornflower, geranium, gloxinia, impatiens, lily, pansy, pothos, peperomia, primrose, ragweed, rosemary, caper spurge, and sainfoin (crown rot). Although *Pythium* flourishes best in the low oxygen content of poorly drained soils, *Rhizoctonia*, causing similar root rots, is serious in well-drained soils. On poinsettia, dark brown lesions at or above soil level are often covered with brown mycelium; the leaves turn yellow and drop, the roots rot, and the plant dies. **Web Blight** and **Stem Canker** on alfalfa. **Damping-off** and **Bottom Rot** on Cichorum (endive, escarole and witloof chicory) and Nicotiana.

Rhizoctonia tuliparum. **Gray Bulb Rot** of tulips, in northeastern and Pacific states. The most conspicuous sign of this disease is a bare patch in spring where tulip shoots should be showing. Occasionally an infected bulb will produce some above-ground growth, but the plants are slow and often wither and die before flowering. Bulbs rot from the top down; mycelium forms felty masses between scales; on bulbs and in surrounding soil are masses of brown to black, flattened sclerotia, composed of the yellow-brown, thin-walled irregular cells typical of *Rhizoctonia*. These can survive in soil for years, germinating to infect bulbs after planting or in very early spring. Occasionally sclerotia are transported on bulbs, but the bulbs are usually so noticeably diseased that they are not sold.

Control. Remove soil and plants from affected area and for at least 6 inches beyond. Destroy all infected bulbs at harvest. Use a 4- to 5-year rotation.

Rhizopus

Zygomyetes, Mucorales

Sporangium large, globose, multispored, with a columella and a thin wall; sporangiola and conidia lacking. Sporangiophores arise in fascicles from aerial arching stolons, which develop rhizoids at point of contact with substratum (Fig. 2.2).

Rhizopus arrhizus. **Soft Rot** on gladiolus corms, light brown and on beet.
Rhizopus arrhizus (formerly *Rhizopus oryzae*). **Head Rot** on sunflower.
Rhizopus nigricans (Syn. *R. stolonifer*), the common black bread mold. **Soft Rot** of sweetpotato and other vegetables; **Rhizopus Rot**, **"Whiskers," Leak** of peach, strawberry, and other fruits. This is one of the more serious storage rots of sweetpotato, soft, watery, progressing rapidly, with rotting complete inside 5 days after visible infection. The tuber is brownish within, covered with a coarse whiskery mycelial growth; there is a mild odor. Cucurbits, crucifers, carrots, beans, lima beans, onions, peanuts, potatoes, Jerusalem artichoke, and guava are susceptible to this black mold. Nancy Hall and Southern Queen are among the more resistant varieties of sweetpotato. To prevent rot, cure at 80° to 85°F for 10 to 14 days, at high humidity, to permit rapid corking over of wounds; then store at 55°F.
The fungus is a weak parasite on ripe fruit – peach, fig, strawberry, citrus, persimmon, pear, avocado and melons. A coarse cottony mold appearing in wounds and over the surface is covered with sporangia, white when young, black at maturity. A watery fluid with an offensive odor leaks from the soft fruit. Avoid wounding in harvesting; do not pack overripe fruit; keep at low temperature in transit and market. Amaryllis, lily, and tulip bulbs may be infected.
Rhizopus oryzae (see *Rhizopus arrhizus*). **Head Rot** on sunflower.
Rhizopus stolonifer. **Soft Rot** of *Euphorbia trigona*.

Roesleria

Ascomycetes, Helotiales

Mycelium inconspicuous; apothecia cup-shaped, opening more or less completely; asci disappearing early, leaving a persistent mass of spores and paraphyses. Spores hyaline, one-celled, globose.

Roesleria hypogaea. **Root-Rot** of grape.

Rosellinia

Ascomycetes, Xylariales

Perithecia smooth, ostiole simple or with a low papilla; with a subicle under the fruiting layer; paraphyses present; spores olive to brown, one-celled.

Rosellinia necatrix (Syn. *Dematophora*). **White Root Rot** of fig, grape, avocado, apricot, cherry, apple, pear, peach, walnut, holly osmanthus, privet and poplar. This is like Armillaria root rot in that all trees in a certain area are killed, but there are no rhizomorphs or toadstools formed. A white mycelial growth on surface of affected roots turns black and cobwebby. During wet weather a delicate mold forms on surface of bark and on soil around base of tree. Foliage is sparse and wilting, growth slow or none. Crabapples are quite resistant. Plums and apricots can be grown on resistant understock.

Schizophyllum

Basidiomycetes, Aphyllophorales

Pileus leathery; stipe lateral or none; edge of gills split; spores white.

Schizophyllum commune. **Wound Rot**, common on dead parts of living trees– maple, boxelder, almond, acacia, ailanthus, birch, catalpa, hickory, peach, pecan and citrus, fig. Fruiting bodies are small, thin, sometimes lobed, up to 2 inches wide, fan-shaped with gray-white downy upper surface, brownish forked gills on underside, common on fruit trees. This pathogen also causes wood decay and decline of apple.

Sclerotinia

► Blights.

Botryotinia narcissicola (formerly *Sclerotinia narcissicola*). **Narcissus Smoulder**. Perhaps the fungus should be transferred to *Botryotinia*, since there is a conidial stage. The disease is a decay of stored narcissus bulbs, also known on snowdrop, and a rot of foliage and flowers in the open, especially during cold wet seasons. Leaves are distorted, stuck together as they emerge from soil. Sclerotia are small, black, flattened bodies, up to 1/2 inch long when several grow together, just below outer papery bulb scales. In prolonged storage there is a yellow-brown rot.

Control. Remove and destroy diseased plants as soon as noticed; destroy weeds to provide air circulation; spray with bordeaux mixture; discard rotting bulbs at harvest; change location every year.

Sclerotinia homoeocarpa. **Dollar Spot**. **Small Brown Patch** of turf on bent grasses, fescues and bluegrass. Spots are brown at first, then bleached and straw-colored, about 2 inches in diameter but coalescing to large irregular patches. While leaves are being killed, a fine white cobwebby growth of mycelium can be seen in early morning when dew is present.

Sclerotinia intermedia. **Stem Rot**, market disease of celery, carrot and salsify.

Sclerotinia minor. **Stem Rot** of lettuce, celery, carrot, cocklebur, Austrian winter pea, lana woolly pod vetch, phacelia and basil; also stem rot on fennel, root and crown rot on cabbage, crown rot and wilt on *Cichorium* (*radicchio*). **Root and Pod Rot** of peanut. Resembles rot due to *S. sclerotiorum*, but sclerotia are much smaller. **Crown Rot** of pepper.

Sclerotinia narcissicola (see *Botryotinia narcissicola*). **Narcissus Smoulder**. Perhaps the fungus should be transferred to *Botryotinia*, since there is a conidial stage.

Sclerotinia sclerotiorum. **Black Rot** of bulbous iris, hyacinth, narcissus and tulip. Iris fails to start growth, or plants turn yellow, wilt, and die, often in clumps. Bulbs are covered with thin gray masses of mold with black irregular sclerotia between scales. Tulip leaves develop reddish color early in spring, wilt and die; stems and bulbs are rotted into a crumbly mass of fragments and black sclerotia. This is a cool-temperature fungus that stops action about the time the heat-loving *Sclerotium rolfsii* starts in. Remove diseased plants and surrounding soil as soon as noticed. Discard all small bulbs at harvest; plant healthy bulbs in clean soil. The pathogen supposedly dies out after 2 years in soil without suitable host.

Sclerotinia sclerotiorum. **Calyx-End Rot** on apple and **Root and Pod Rot** of peanut, **Root and Stem Rot** of alfalfa.

Sclerotinia sclerotiorum. **Green Fruit Rot** of almond, peach, apricot, fig and strawberry; **Rhizome Rot** of ginseng. In almond, young shoots and fruits are killed and wither soon after petals fall. Infection takes place through jackets from apothecia produced under trees where weeds or crop plants have been previously infected with cottony rot. Losses are serious only when there is continuous wet weather during and after blooming. Spraying for brown rot helps to control green rot. Shaking or jarring trees after bloom to remove jackets from young fruits is suggested.

Sclerotinia sclerotiorum. **Leaf and Crown Necrosis** of African daisy; **Root Rot** and **Wilt** of peanut. **White Mold Rot** of soybean.

Sclerotinia sclerotiorum (*S. libertiana*). **Lettuce Drop**, **Watery Soft Rot** of endive; **Pink Rot** of celery, **Cottony Rot** of bean, carrot, parsnip, cabbage, and other crucifers and cucurbits. In lettuce, older leaves wilt and fall flat on the ground, leaving center leaves erect, but these are soon invaded by mycelium and reduced to a slimy wet mass. In continued moisture a thick, white cottony mold is formed, bearing large black sclerotia up to the size of peas (see Fig. 3.53). They winter in the soil, send up groups of apothecia in spring. These are brown, cup- to saucer-shaped, up to an inch across, on a stalk. Ascospores are ejected in a veritable cloud; there is no known conidial stage.

Control. In commercial celery fields deep plowing or flooding is used to inhibit apothecial production. Sterilize seedbed soil before planting.

Sclerotinia sclerotiorum. **Stem Rot** of pepper, cocklebur, tomato, and many ornamentals – aconite, basil, calendula, chervil, canola, chrysanthemum, cynoglossum, dahlia, daisy, delphinium, Gaillardia, gazania, hollyhock, peony, purple coneflower, snapdragon, sunflower, zinnia, and others. The same sort of cottony mold is formed on flower stems as on vegetables, but here the sclerotia are usually inside the pith and so are rather

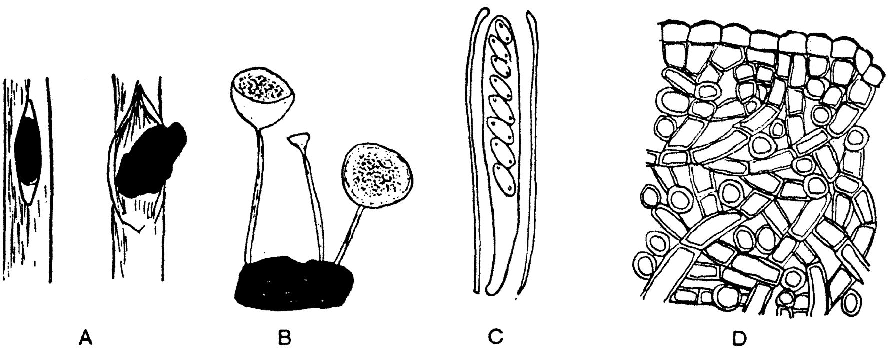


Figure 3.53 *Sclerotinia sclerotiorum*. **A** sclerotium formed in pith of stem and one falling out from broken stem; **B** apothecia produced from sclerotium on ground; **C** ascus with paraphyses; **D**, section through sclerotiorum, with colorless medulla and dark wall on rind cells

long and thin. You can feel them by running thumb and finger along the stem; sometimes the cottony mycelium, or cracks in the stem, or one or two external sclerotia indicate their presence. They are common in peony stems. When sclerotia are formed in flowers, the shape corresponds to floral parts. Sunflowers have large compound sclerotia.

Control. Cut out and destroy affected parts, trying to keep sclerotia from falling out onto soil. Dusting with sulfur sometimes checks rapid spread of mycelium.

Sclerotinia trifoliorum. **Root Rot**, **Stem Rot** of cocklebur and alfalfa.

Sclerotium

► Blights.

Sclerotium cepivorum. **White Rot** of onion, shallot and garlic. Affected plants die from a rotting at the neck, at which point there is a surface crust of small black sclerotia and a thin weft of white mycelium. The sclerotia are smaller and rounder than those of *Botrytis*. Roots are often rotted off, and sometimes spots in a field covering several square yards are infested.

Sclerotium rolfsii (including *Sclerotium delphinii*). **Crown Rot** of delphinium, iris, ajuga, aconite, quinoa, sainfoin, kiwi, and many other ornamentals and vegetables, **Root Rot** and **Wilt** of peanut, **Wet Scale Rot** of narcissus, **Southern Blight**. For a full discussion see *Pellicularia rolfsii* under Blights.

Seaverinia

Ascomycetes, Helotiales

Apothecia shallow, cup- to disc-shaped; a stroma formed but no definite sclerotia; conidia botryose.

Seaverinia geranii (Syn. *Sclerotinia geranii*). **Rhizome Rot** on geranium.

Steccherinum

Basidiomycetes, Aphyllophorales

This genus has been separated off from *Hydnum*. The pileus is sessile or substipitate and laterally attached, on a woody substratum; spines are terete or flattened; cystidia present; spores white, smooth.

Climacoden septentrionalis (formerly *Steccherinum septentrionale* Syn. *Hydnum septentrionale*) **White Spongy Rot** of heartwood of living maples, beech, hickory, and other hardwoods. A zone of brown discolored wood is around the white rot area, and there are fine black zone lines. The fruiting bodies are large, soft, soggy, creamy white, in very large, bracket-shaped clusters on trunks.

Hericium obietis (formerly *Steccherinum abietis* Syn. *Hydnum abietis*). **Brown Pocket Rot** of heartwood of living firs and western hemlock in Pacific Northwest. Elongated pockets, empty or with white fibers, are separated by firm reddish brown wood. Sporophores are like coral, white to cream, up to 10 or 12 inches high and wide, usually on dead trees, sometimes in wounds of living trees.

Steccherinum abietis Syn. ***Hydnum abietis*** (see *Hericium obietis*). **Brown Pocket Rot** of heartwood of living firs and western hemlock in Pacific Northwest.

Steccherinum septentrionale Syn. **Hydnum septentrionale** (see *Climacoden septentrionalis*) **White Spongy Rot** of heartwood of living maples, beech, hickory, and other hardwoods.

Stereum

Basidiomycetes, Aphyllophorales

Effused-reflexed to stipitate; spore-bearing surface smooth, pale brown, upper surface with a velvety coating of hairs, formed in several distinct layers; gloeocystidia and cystidia present or lacking; spores smooth, colorless.

Chondrostereum purpureum (formerly *Stereum purpureum*). **Silver Leaf**, **Sapwood Rot**, common on plums and other fruit trees, sometimes important on apples, occasional on shade and ornamental trees, widespread but more serious in the Northwest. The fungus enters through wounds; grows first in heartwood, and then kills sapwood and bark; infected branches develop foliage with dull leaden or metallic luster. If the disease is not checked, the entire tree may be lost. The sporophores appear after death, resupinate to somewhat shelf-shaped, with purple undersurface.

Stereum fasciatum (Syn. *S. ostrea*). **Brown Crumbly Rot**, mostly on slash, sometimes on maple and birch. Thin, leathery grayish sporophores with undersurface light brown, smooth.

Stereum hirsutum. **Wood Rot**, **Sapwood Wound Rot**, occasionally near wounds of living trees – birch, maple, hickory, mountain-mahogany, eucalyptus, peach, and others. Thin, leathery crustlike sporophores have hairy, buff to gray upper surface, smooth gray undersurface.

Control. Remove branches and burn at first sign of silvering. Protect trees from wounds; paint pruned surface with bordeaux paste or other disinfectant; keep brush removed from orchard.

Stereum purpureum (see *Chondrostereum purpureum*). **Silver Leaf**, **Sapwood Rot**, common on plums and other fruit trees, sometimes important on apples, occasional on shade and ornamental trees, widespread but more serious in the Northwest.

Stereum sanguinolentum. **Red Heart Rot** of slash and living conifers – firs and eastern white pine. Fruiting bodies are small, not over 2 inches wide; upper surface is a silky pale olive buff; lower surface "bleeds" readily when wounded, dries to grayish brown. Sporophores are produced in profusion on dead wood, occasionally on dead branches of living trees.

Streptomyces

Schizomycetes, Actinomycetales

Intermediate form between bacteria and fungi. Much-branched mycelium that does not fragment in bacillary or coccoid forms; conidia in chains on sporophores; primarily soil forms, some parasitic.

Streptomyces ipomoea (Syn. *Actinomyces ipomoea*) **Soil Rot or Pox** of sweetpotatoes, general New Jersey to Florida and in the Southwest. This pathogen also infects *Jacquemontia*. Leaves are small, pale green to yellow; plants are dwarfed, make little or no vine growth, and may die before end of the season; the root system is poorly developed with most roots rotted off, or breaking off if plant is pulled from the soil. Small dark lesions are formed on stems below the soil line. Pits with jagged or roughened margins, often coalescing, are formed on mature roots. The rot is found in soils at pH 5.2 or above; and is worse in dry soils and seasons. Variety Porto Rico is very susceptible.

Control. Apply sulfur to acidify soil to pH 5.0.

Stromatinia

Ascomycetes, Helotiales, Sclerotiniaceae

Apothecia arising from a thin, black, subcuticular, effuse sclerotium or stroma; small black sclerotia are borne free on mycelium, not giving rise to apothecia. There is no conidial stage; apothecia resemble those of *Sclerotinia*.

Stromatinia gladioli (Syn. *Sclerotinia gladioli*). **Dry Rot** of gladiolus, also found on crocus, freesia and tritonia. Lesions on corms start as reddish specks, with slightly elevated darker border; spots enlarge, and centers become sunken, dark brown to black with lighter raised edges; they grow together into irregular areas. On husks the lesions are tobacco brown. Very small black sclerotia are formed on husks, in corm lesions, and on dead stems. Plants in the field turn yellow and die prematurely owing to decay of leaf sheath. Corms may appear normal when dug, the rot developing in storage. The disease is more prevalent in heavy soils, and the fungus can survive several years in soil. Apothecia have been produced artificially by fertilizing receptive bodies on sclerotia with spermatia (microconidia). They are densely crowded, 3 to 7 mm broad, on stipes 6 to 10 mm high.
Control. Use soil with good drainage and a 4-year rotation. Removing husks before planting helps to reduce gladiolus rot diseases. Cure corms rapidly after harvest.
Stromatinia narcissi. Large-scale speck fungus on narcissus and zephyranthes. Black, thin, round, flat sclerotia 1/2 to 1 mm, adhere firmly to outer scales. The fungus is mostly on bicolor varieties and seems to be saprophytic without causing a definite disease.

Thielaviopsis

Deuteromycetes, Hyphomycetes

Hyphae dark; two kinds of conidia-small, cylindrical, hyaline endogenous spores and large, ovate, dark brown exogenous spores, both formed in chains.

Thielaviopsis basicola. **Black Root Rot**, seedling root rot of tobacco and many vegetables – bean, carrot, corn, chickpea, lentil, okra, onion, pea, tomato, corn-salad, vinca, and watermelon; and ornamentals – begonia, cyclamen, gerbera, elm, oxalis, lupine, pelargonium, peony, poinsettia, pansy, scindapsus, and others. There is blackening and decay of roots; young plants damp-

off and die; older plants are stunted, with the decay proceeding until all roots are destroyed. Stem discoloration extends 2 to 3 inches above the soil line. The fungus lives in soil as a saprophyte, entering through nematode wounds. Hyaline conidia produced inside conidioles are forced out through hyphal tips. Chlamydospores are larger, dark, club-shaped, with several cells; they break up so that each pillbox acts as a spore. This disease is especially serious on poinsettia, dwarfing plants, causing misshapen leaves and flower bracts.
The rot is most destructive in heavy, cold, slightly acid to alkaline soils well supplied with humus. Long wet periods after transplanting increase rot. Soils with pH lower than 5.6 or sandy soils low in organic matter are less conducive to disease.
Control. Sterilize soil for seedbeds; use clean pots for poinsettias and other greenhouse plants; reduce pH with sulfur or by using half peat moss and half soil.

Trametes

Basidiomycetes, Aphyllophorales

Pileus without stipe, sessile to effuse-reflexed, firm; hymenium white or pallid, punky to corky, not friable when dry; tubes unequally sunken.

Trametes suaveolens. **White Wood Rot** of willow and poplar, after wounding. A dry, corky decay with an anise odor begins in lower trunk and progresses upward. Leathery to corky sporophores 6 inches wide are white when young, gray to yellow with age.

Trichoderma

Deuteromycetes, Hyphomycetes

Conidia in heads on conidiophores divided into two or three tips, a single head on each tip; spores hyaline, one-celled.

Trichoderma viride. **Green Mold Rot, Cosmopolitan** on narcissus, also on shallot, garlic, occasional on citrus, but saprophytic. This fungus has an antibiotic or antagonistic effect on *Rhizoctonia, Pythium*, and other damping-off fungi and is quite helpful in reducing Armillaria root rot and crown rot due to *Sclerotium rolfsii*.
Trichoderma harzianum. **Fruit Rot** of apples in storage.

Trichothecium

Deuteromycetes, Hyphomycetes

Conidiophores long, unbranched; conidia two-celled, hyaline or bright, single, at apex of conidiophore; upper cell usually larger than basal cell; mostly saprophytic.

Trichothecium roseum. **Fruit, Storage Rot** on tomato, fig, celery, carrot, occasional on quince and pear; a pink mold. **Pink Mold Rot** on plum, nectarine and peach.

Ustulina

Ascomycetes, Xylariales

Stroma globoid, cupulate to pulvinate; carbonaceous, black, somewhat hollow; spores dark, one-celled.

Ustulina deusta. **White Heart Rot**, a brittle white rot with prominent black zones in butts of living hardwoods; prevalent on sugar maple sprouts. Black crusts appear on stumps, logs, and on flat cankered areas of American beech.

Valsa

► Cankers and Diebacks.

Valsa ambiens subsp. **leucostomoides**. Causing decay around holes of tapped sugar maples.

Leptographium (Verticicladiella)

Deuteromycetes, Hyphomyceres

Conidiophores upright, tall, brown, branched only near apex, penicillate; conidia (sympodulospores) hyaline, one-celled, ovoid to clavate, often curved, apical on sympodially formed new growing points, in slime droplets.

Leptographium abietinum (formerly *Verticicladiella abietina*). **Root Rot** on white pine.

Leptographium penicillata (formerly *Verticicladiella penicillata*. **Root Rot** on white pine.

Leptographium procera (formerly *Verticicladiella procera*. **Root Rot** and **Decline** of eastern white pine, sand pine and red pine.
Leptographium wagenerii (formerly *Verticicladiella wagenerii*. **Root Rot** on fir and pine.
Verticicladiella abietina (see *Leptographium abietinum*). **Root Rot** on white pine.
Verticicladiella penicillata (see *Leptographium penicillata*). **Root Rot** on white pine.
Leptographium procera (see *Verticicladiella procera*). **Root Rot** and **Decline** of eastern white pine, sand pine and red pine.
Leptographium wagenerii (see *Verticicladiella wagenerii*). **Root Rot** on fir and pine.

Xylaria

Ascomycetes, Xylariales

Stroma is upright, simple or branched; perithecia, immersed laterally, are produced after conidia; spores dark, one-celled.

Xylaria hypoxylon. **Root Rot** of hawthorn and gooseberry.
Xylaria mali. **Black Root Rot** of apple, also honey locust. Wood is soft, spongy, dirty white, with narrow conspicuous black zones forming fantastic patterns. Roots are covered with thin compact white mycelium, which changes to black incrustations. Fruiting bodies are dark brown to black, club-shaped, 1 to several inches high, united at the base, extending upward like a fan. The disease is not common, and where it does occur, only a few trees are killed.
Xylaria polymorpha. On decaying wood, identified by cylindrical thumb-like fruiting bodies.

RUSTS

Rust fungi belong to the Uredinales, a highly specialized order of the Basidiomycetes. In common with mushrooms they have spores of the sexual stage borne in fours on a club-shaped hypha known as a basidium, but apart from this they differ very decidedly from woody and fleshy Basidiomycetes. The term rust is applied both to the pathogen and to the disease it inflicts. There are more than 4000 species of rusts, all obligate parasites on ferns or seed plants. Many are heteroecious, completing their life cycle on two different kinds of plants; but some are autoecious (monoecious), having all spore forms on a single host species. There are only two families, Melampsoraceae and Pucciniaceae.

Many rusts show physiological specialization, the existence within a species of numerous strains or races that look alike but attack different varieties of crop plants, thus greatly complicating the problem of breeding for rust resistance. Rusts with a complete life cycle have five different spore forms, numbered 0 to IV.

0. *Pycniospores* (spermatia) formed in *pycnia* (spermagonia). The pycnia resemble pycnidia of Ascomycetes, are usually on upperside of leaves. They discharge one-celled pycniospores with drops of nectar, and these, usually distributed by insects attracted to the sweet secretion, function in fertilization.
I. *Aeciospores* (aecidiospores), one-celled, orange or yellow, formed, often in chains, in a cuplike sorus or *aecium*, which has a peridium (wall) opening at or beyond the surface of the host.
II. *Urediospores* (uredospores, summer spores, red rust spores), one-celled, walls spiny or warty, reddish brown, on stalks or in chains in a *uredium* (uredinium or uredosorus), over which the epidermis of the host is broken to free the spores. Resting II spores, formed by some rusts, have thicker and darker walls.
III. *Teliospores* (teleutospores, winter spores, black rust spores), one or more cells, in *telia* (teleuto sori), either on stalks, as in the family Pucciniaceae, or sessile, in crusts or cushions as in the Melampsoraceae.

IV. *Basidiospores* (sporidia) on a basidium or promycelium formed by the germinating teliospore. Basidium is usually divided transversely into four cells, with one sporidium formed from each cell at the tip of a sterigma.

In heteroecious rusts spore stages 0 and I are formed on one host and II and III on another, and are so indicated in the information given with each species. Stage IV always follows III on germination. Although most autoecious rusts have all spore forms, on one host, there are a few short-cycle (microcylic) rusts with some spore stages dropped out. For a detailed life history of a heteroecious rust, ▸ *Puccinia graminis*.

Gardeners frequently mistake a reddish discoloration of a leaf, perhaps due to spray injury or weather or a leaf-spot fungus, for rust. True rust is identified by the presence of rust-colored spores in powdery pustules or perhaps gelatinous horns. With rusts, the discoloration of tissue is yellowish, not red, and it is due to increased evaporation from the broken epidermis. Plants are often stunted.

Losses in food crops due to rust have been enormous since the beginning of history. The Romans had a festival to propitiate the rust gods. Now we try to do it by removing the alternate host, barberry to save wheat, black currants to save white pine; or by developing more and more resistant varieties for the ever increasing rust strains; or by the use of fungicides, classically sulfur, latterly some of the carbamates, and, in a few cases, antibiotics.

Achrotelium

Melampsoraceae. Telia on underside of leaves; spores one-celled at first, four-celled on germination, stalked.

Achrotelium lucumae. II, III on lucuma and egg fruit, Florida.

Aecidium

This is a form genus, a name applied to the aecial stage where the full cycle is unknown and 0 and I are the only spores. Aecia have a peridium and catenulate spores. There are many species.

Aecidium avocense. On poppy-mallow, probably aecial stage of *Puccinia avocensis*.

Aecidium conspersum. On houstonia and galium, Wisconsin.
Aecidium rubromaculans. On viburnum, Florida.

Angiospora

► *Physopella.*

Aplopsora

Melampsoraceae. Teliospores sessile, hyaline, one-celled, in a single layer; aecia unknown.
Aplopsora nyssae. On tupelo, II, III.

Baeodromus

Pucciniaceae. Spores one-celled; telia pulvinate, erumpent; short chains of spores.

Baeodromus californicus. On senecio, III.
Baeodromus eupatorii (see *Coleosporium steviae*). On eupatorium.
Coleosporium steviae (formerly *Baeodromus eupatorii*). On eupatorium.

Bubakia (Phakopsora)

Melampsoraceae. Telia indehiscent, lenticular, spores formed in irregular succession, one-celled. Uredia without peridium or paraphyses.

Bubakia erythroxylonis. On erythroxylon.

Caeoma

Form genus. Aecia with catenulate spores but no peridium.

Caeoma faulliana (see *Melampsora medusae*). **Needle Rust** on alpine fir. Aecia orange-yellow, on needles of current year.
Caeoma torreyae. On torreya, California.
Melampsora medusae (formerly *Caeoma faulliana*). **Needle Rust** on alpine fir. Aecia orange-yellow, on needles of current year.

Cerotelium

Pucciniaceae. Spores one-celled; teliospores in a many-layered mass; hyaline, not exserted through stomata; aecia with peridium; uredia with paraphyses; spores borne singly.

Cerotelium dicentrae. 0, I on bleeding heart; II, III on *Urticastrum*.
Cerotelium fici (*Physopella fici*). **Fig Rust**, II, III on common fig, Florida strangler fig and osage-orange, Alabama, Florida, Louisiana, Minnesota, South Carolina, Texas.

Chrysomyxa

Melampsoraceae. Teliospores in cylindrical or branching chains; promycelium exserted; urediospores typically in short chains; uredia without peridium.

Chrysomyxa arctostaphyli. On bearberry, III.
Chrysomyxa chiogenis. II, III on creeping snowberry; 0, I on spruce.
Chrysomyxa empetri. II, III on crowberry; 0, I on red and white spruce. Aecia on upper and lower surfaces of needles.
Chrysomyxa ilicina. II, III on American holly.
Chrysomyxa ledi. 0, I, on black, red and Norway spruce; II, III on underside of leaves of *Ledum* spp.
Chrysomyxa ledi var. **cassandrae**. **Spruce Needle Rust**. 0, I on black, red, blue and Engelmann spruce; II, III on bog rosemary (*Chamaedaphne*). May become epidemic on spruce, causing considerable defoliation.
Chrysomyxa ledi var. **groenlandici**. On Labrador-tea, Michigan, New Hampshire.
Chrysomyxa ledi var. **rhododendri**. II, III on rhododendron, Washington. A European rust first noted on Pacific Coast in 1954, apparently entering despite quarantine on nursery stock. Yellow uredia on leaves.
Chrysomyxa ledicola. 0, I on white, black red, blue, Engelmann, and Sitka spruce; II, III on upperside of leaves of *Ledum* spp. Spruce needles may be so discolored that trees appear yellow.
Chrysomyxa moneses. On Sitka spruce and moneses.
Chrysomyxa piperiana. 0, I on Sitka spruce; II, III on underside leaves of *Rhododendron californicum*, California, Oregon, Washington.
Chrysomyxa pirolata (*C. pyrolae*). 0, I on cones of black, blue, Engelmann,

Norway, red and white spruce; II, III on pyrola. Aecia are on upperside of cone scales; infected cones turn yellow, produce no seed.

Chrysomyxa weirii. **Spruce Needle Rust**. III on Engelmann and red spruce. Waxy orange to orange-brown elongate or elliptical telia occur on 1-year needles. This is the only spore stage known; teliospores can reinfect spruce.

Coleosporium

Melampsoraceae. Pycnia and aecia are on pines; uredia and telia on dicotyledons. Pycnia subepidermal or subcortical, flattish, linear, dehiscent by a slit; aecia on needles, erumpent, with prominent peridium, spores ellipsoid or globular; uredia erumpent, powdery without peridia; urediospores globose or oblong, catenulate, with verrucose (warty) walls; telia indehiscent, waxy, gelatinous on germination; spores sessile or obscurely catenulate, one-celled, smooth but with thick and gelatinous walls.

Coleosporium apocyanaceum. 0, I on loblolly, longleaf, and slash pines; II, III on *Amsonia* spp. in the Southeast.

Coleosporium asterum (*C. solidaginis*). **Needle Blister Rust** of pine. 0, I on all two- and three-needle pines in eastern United States; II, III on aster and goldenrod, on China aster (except far South), on golden aster (*Chrysopsis*), erigeron, grindelia, seriocarpus, and other composites. This blister rust on pine needles has pustules higher than they are long, in clusters or short rows. The rust is fairly common on ornamental pines in gardens, wintering on aster and related composites. Older needles of young pines may be severely infected, with white aecia conspicuous in spring and early summer. Aster leaves have bright orange-yellow spore pustules on undersurface. Destroy goldenrod near pines.

Coleosporium crowellii. III only stage known; on needles of pinon and limber pines, Arizona, Colorado, New Mexico, Utah, Nevada, and California.

Coleosporium delicatulum. **Pine Needle Rust**. 0, I on two- and three-needle pines; II, III on goldenrod and euthamia.

Coleosporium helianthi. 0, I on two- and three-needle pines, especially in the Southeast; II, III on silphium and parthenium.

Coleosporium helianthi. **Sunflower Rust**. 0, I on pitch and short-needle pines; II, III on wild and cultivated sunflower, Jerusalem artichoke and heliopsis. Sunflower leaves, with brown rust pustules, dry up and drop. Control is not easy.

Coleosporium ipomoeae. 0, I on southern and Chihuahua pines; II, III on moonflower, morning-glory, sweetpotato, jacquemontia, and quamoclit; most abundant in warmer regions. The uredia are orange-yellow, telia deep reddish orange on sweetpotato.

Coleosporium jonesii. 0, I on pinon pine; II, III on flowering currant and gooseberry.

Coleosporium lacinariae. 0, I on loblolly, longleaf, and pitch pines; II, III on liatris.

Coleosporium mentzeliae. On mentzelia.

Coleosporium minutum. 0, I on loblolly and spruce pines; II, III on forestiera.

Coleosporium pacificum. 0, I on Monterey, Coulter, and Jeffrey pines; II, III on marigold, sunflower, tarweed, and other composites.

Coleosporium pinicola. III on Virginia or scrub pine.

Coleosporium tussilaginis. 0, I on pitch, red, and Virginia pines; II, III on campanula, lysimachia, and specularia, Underside of bluebell leaves are covered with orange to reddish brown pustules. Leaves dry; plants are stunted.

Coleosporium tussilaginis. 0, I on Scotch pine; II, III on sow-thistle.

Coleosporium tussilaginis. 0, I, unknown; II, III on senecio.

Coleosporium vernoniae. 0, I on two- and three-needle pines in South; II, III on elephantopus.

Coleosporium vernoniae. 0, I on various two- and three-needle pines; II, III on ironweed.

Coleosporium viburni. 0, I, unknown; II, III on *Viburnum* spp.

Cronartium (Causing Blister Rusts)

Melampsoraceae. Heteroecious; pycnia and aecia on trunk and branches of pine; uredia, telia on herbaceous or woody dicotyledons.

Pycnia on stems, caeomoid, forming blisters beneath host cortical layer; dehiscent by longitudinal slits in bark; aecia on trunks, erumpent, with peridium sometimes dehiscent at apex, more often spliting irregularly or circularly at side; aeciospores ellipsoid with coarsely warted walls, sometimes with smooth spot on one side. Uredia on underside of leaves or on stems of herbaceous hosts; delicate peridium, dehiscent at first by a central pore; urediospores borne singly on pedicels, ellipsoidal with spiny walls; telia erumpent, often coming from uredia; catenulate, one-celled teliospores often form a extended cylindrical or filiform column, horny when dry (see Fig. 3.54).

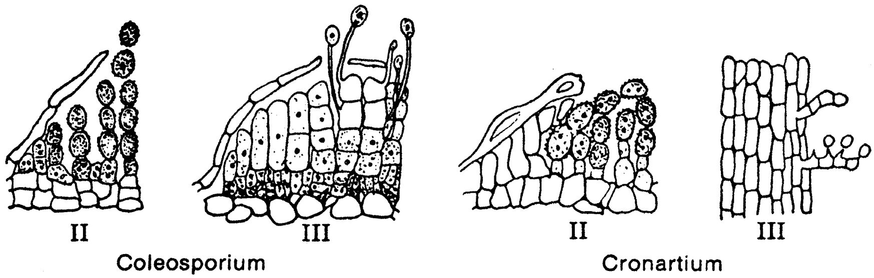


Figure 3.54 Pine Rusts. *Coleosporium asterum*, uredial (II) and telial (III) stages on aster, teliospores germinating *in situ*. *Cronartium ribicola*, II and III stages on currant

Blister rusts are characterized by swellings that are globose, subglobose, or fusiform, depending on species. A rust on a pine stem is invariably a *Cronartium*, although this stage has often gone under the name of *Peridermium*.

Cronartium appalachianum (*Peridermium appalachianum*). I on Virginia pine, North Carolina, Tennessee, Virginia, West Virginia. Girdling bark lesions with columnar aecia.

Cronartium coleosporioides. **Ponderosa Pine Rust**, widespread in Rocky Mountains; II, III on Indian paintbrush.

Cronartium coleosporioides (*C. filamentosum*). **Western Gall Rust**, **Paintbrush Blister Rust**. 0, I on lodgepole, ponderosa and Jeffrey pines, in West; II, III on Indian paintbrush, birds-beak, owls-clover and wood-betony. Slight swellings are formed on twigs, trunks, and branches; many lodgepole pine seedlings are killed.

Cronartium comandrae. **Comandra Blister Rust**. 0, I on ponderosa, Arizona, and lodgepole pines in West and pitch, mountain,jack, loblolly, Austrian, Scotch, and maritime pines in the East; II, III on bastard toadflax (*Comandra* spp.). Destructive effect is limited to distribution of toadflax, which is widespread but locally restricted to small areas. Ponderosa pine suffers most severely, with many seedlings and saplings destroyed; occasionally a large tree is attacked.

Cronartium comptoniae. **Sweet-Fern Blister Rust**. 0, I on two- and three-needle pines; II, III on sweet-fern and sweet gale in northern pine regions and south to North Carolina, and on Pacific wax-myrtle on Pacific Coast. Young pines may be girdled and killed, but are fairly safe after attaining a trunk diameter of 3 inches. Losses in nurseries and plantations are high, especially among lodgepole and ponderosa pines. Affected stems swell slightly near the base with long fusiform swellings or depressed streaks on eastern hard pine; pitch oozes out from insect wounds in these areas. Killing of main stem often results in multiple-stemmed shrublike trees. Orange aecia appear on 3-year seedlings, preceded by pycnia the year before; spores are wind-borne many miles to herbaceous hosts.

Control. Remove *Myrica* species for several hundred yards around nurseries or pine plantations, and allow no large groups within a mile.

Cronartium conigenum. **Pine Cone Rust**. 0, I on cones of Chihuahua pine; II, III on oaks in Southwest. Cones develop in large galls producing aecia with distinct, erumpent peridium 2 or 3 years after infection.

Cronartium harknessii (see *Endocronartium harknessii*). **Western Gall Rust**. 0, I on Jeffrey, ponderosa, lodgepole, and digger pines; II, III on Indian paintbrush, lousewort, owls-clover, or omitted, with direct infection from pine to pine.

Cronartium occidentale. **Pinon Blister Rust**. 0, I in pinon and Mexican pinon; II, III on currant, gooseberry and flowering currant. This rust cannot be told from whitepine blister rust on *Ribes* hosts, but is differentiated by the type of pine attacked. Aecia on Mexican or singleleaf pinon are distinct sori; on pinon they form broad layers under bark.

Cronartium quercuum f. sp. **fusiforme**. **Rust** on pine.

Cronartium quercuum f. sp. **fusiforme**. **Southern Fusiform Rust**, 0, I on hard pines in southern states, especially loblolly, slash, and pitch pine; II, III on evergreen oaks on underside of leaves. Pine stems have pronounced spindle-shaped swellings, sometimes with witches' brooms. Branch infections that do not reach the main trunk are not serious, but those that go on to the trunk may kill the tree. Longleaf pines are rather resistant, and shortleaf *P. echinata* almost immune. Pines well spaced in good locations grow more rapidly and may have more rust than those in poor sites. It has also been reported on oaks.

Control. Prune branches yearly before swellings reach main stem.

Cronartium quercuum (*C. cerebrum*). **Eastern Gall Rust**. 0, I on pines, especially scrub and shortleaf in the South; II, III on chestnut, tanbark and oak. Globose to subglobose galls are formed on pine stems; in spring aecia break through the bark in more or less cerebroid (brainlike) arrangement.

Cronartium ribicola. **White Pine Blister Rust**. 0, I on eastern white pine from Maine to Virginia and Minnesota, on western white pine in the Pacific Northwest, on sugar pine in California; II, III on currant, flowering currant and gooseberry. Occurs also on limber pine in Northcentral and Southeastern Wyoming.

This dread disease is supposed to have originated in Asia, whence it spread to Europe, where the eastern white pine introduced from America was very susceptible. White pine blister rust was found in Russia in 1854, and by 1900 had spread over most of Europe. It was recorded on *Ribes* at Geneva, New York, in 1906, but probably was there some years previously. In 1909 it was found on pine, at which time it was learned that infected pines from a German nursery had been widely planted throughout the Northeast. The next year the disease reached Vancouver, British Columbia, in a shipment from a French nursery, whence it spread to Washington, Oregon, Northern California, Idaho, and western Montana. Thus from cheap stock brought in for forest planting has come one of our greatest forest hazards. Our present quarantine laws are designed to prevent such introductions.

The western white sugar and whitebark pines are even more susceptible to blister rust than eastern white pine; but in either case robust, dominant trees are more severely attacked, with frail individuals lightly infected. This however, is partly explained by more vigorous trees having more needles to receive spores. Of the *Ribes* species, black currant is most susceptible and dangerous. Cultivated red currants are somewhat resistant, causing a minimum of pine infection; Viking and Red Dutch varieties are practically immune. Wild gooseberries and skunk currant are highly susceptible in the Northeast, as are western black currant, stink currant, and red flowering currant. The greater the susceptibility of the *Ribes* species, the more spores are produced to inoculate pines, with proportionate damage.

Symptoms and Life History. When a spore arrives on a pine needle from a currant, the first sign of infection is a small golden yellow to reddish brown spot. The next season, or possibly in two years, the bark looks yellowish, often with an orange tinge to the margin of the discolored area, and there may be a spindle-shaped swelling. If such symptoms appear early in the season, pycnia are formed in bark by July or August; but if discoloration is delayed until midsummer, they appear the next year. The male fruiting bodies are small, honey yellow to brown patches, swelling to shallow blisters and rupturing to discharge drops of a yellowish, sweet liquid. After this is eaten by insects or washed away by rain, the lesions turn dark. The next spring or summer aecia push through the bark in the same region. These are white blisters, rupturing to free orange-yellow aeciospores, which are carried away by wind. The bark then dries out and cracks, with death of cambium and underlying wood. The disease has taken 3 to 6 years to reach this stage.

Production of aecia continues yearly until stem is killed beyond the lesion. Dead foliage assumes a conspicuous red-brown color. This “flag” of brown on a green background is the most conspicuous symptom of blister rust before death of the pine. Infection progresses downward from small to larger branches and into trunk. Swellings are not apparent on stems much over 2 inches in diameter on eastern white pine, but in the West they sometimes show up in stems 5 inches through. Larger limbs and trunks sometimes show constriction in the girdled area.

The aeciospores, large, ellipsoidal, with thick, warty walls, are carried by wind great distances to *Ribes* species (they cannot reinfect pine). They send their germ tubes into a currant or gooseberry leaf through stomata, and within 1 to 3 weeks pinhead-size blisters appear in clusters on yellowed leaf tissue. These uredia rupture to release large, ellipsoidal, yellow urediospores with thick, colorless walls and short, sharp but sparse spines. The spores are somewhat moist and sticky, and are windborne short distances to other *Ribes* bushes nearby. There may be up to seven generations in a summer, or the spores may remain viable over winter in uredia; this stage can infect only currant.

In late summer telia follow uredia in the same or new leaf lesions, appearing as short brown bristles on underside of leaves or looking like a coarse felt. Each felty bristle is composed of vertical rows of broad, spindle-shaped spores, which germinate *in situ* to a five-celled promycelium with each of the four upper cells bearing at the point of a sterigma a small, thin-walled, round basidiospore. This cannot reinfect currant and soon dies from exposure to the sun unless the wind blows it immediately to a pine needle. The effective range is around 300 feet except for spores from black currants, which can be carried a mile. The spores from pine to currant can be carried many miles, up to 300. Blister rust is more important at elevations of 1000 feet or over, where it is increased by lower temperatures and more rainfall.

Control. Eradication of the *Ribes* host is definitely effective in controlling white pine blister rust. This means complete removal of black currants and local removal of cultivated red and wild currants and gooseberries within 300 or 900 feet of pines, according to state regulations, taking care to get all the root system capable of resprouting.

Blister rust is seldom found on ornamental pines in cities; the smoke and fumes are unfavorable to the fungus. Elsewhere valuable ornamentals can be saved by cutting off infected branches and cleaning out trunk infection, stripping off diseased bark and a 2-inch side margin, 4-inch margin at top and bottom, of healthy bark. If the cankers are nearer to the trunk than 6 inches, the bark should be excised around the branch stub. The red currant Viking is immune to blister rust, and a couple of black currant hybrids are resistant. Some white pines are exhibiting resistance.

Cronartium stalactiforme (see *Peridermium stalactiforme*). 0, I on lodgepole pines in Rocky Mountain regions; II, III on Indian paintbrush.

Cronartium strobilinum. **Pine Cone Rust**. 0, I on cones of longleaf and slash pines; II, III on evergreen oak. Cones are swollen, reddish; 25 to 90% drop.

Endocronartium harknessii (formerly *Cronartium harknessii*). **Western Gall Rust**. 0, I on Jeffrey, ponderosa, lodgepole, and digger pines; II, III on Indian paintbrush, lousewort, owls-clover, or omitted, with direct infection from pine to pine. Galls are globose, with large, confluent aecia; bark sloughs off in large scales; witches' brooms are formed. A variety of this species, alternate stage unknown, occurs on Monterey and knobcone pines in California.

Control. Remove trees with galls for a distance of 300 yards around nurseries. Do not ship infected trees from nurseries.

Peridermium stalactiforme (formerly *Cronartium stalactiforme*). 0, I on lodgepole pines in Rocky Mountain regions; II, III on Indian paintbrush. The rust enters pine trunks through small twigs, producing diamond-shaped lesions that elongate an average of 7 inches a year, but grow laterally less than 1/2 inch. Removal of diseased trees is the only known control.

Cumminsiella

Pucciniaceae. Autoecious; teliospores two-celled; pycnia and other sori subepidermal; aecia cupulate.

Cumminsiella mirabilissima. 0, I, II, III on barberry and mahonia in the West, Arizona, California, Colorado, Idaho, Montana, Nebraska, New Mexico.

Cumminsiella texana. On barberry, Texas.

Desmella

Pucciniaceae. Uredia and telia subepidermal, protruding in tufts; uredia without peridium or paraphyses. Spores globoid, on pedicels, two-celled.

Desmella aneimiae. On Boston fern, Florida.

Endocronartium

Badisiomycete, Uredinales, Pucciniaceae.

Endocronartium harknessii. **Western Gall Rust or Pine-Pine Gall Rust** on pine.

Endophyllum

Pucciniaceae. Teliospores in form of aeciospores; telia with cupulate peridium.

Endophyllum sempervivi. III on houseleek and hen-and-chickens. Succulent leaves may be covered with reddish pustules. This is not common, but may be serious. Clean out infected parts.
Endophyllum tuberculatum. III on hollyhock and checkermallow.

Frommeella

Pucciniaceae. Teliospores two-to many-septate; aecia and uredia erumpent.

Frommeella duchesneae. II, III on mock-strawberry, false strawberry, or Aztec Indian berry.

Arthuriomyces (Gymnoconia)

Pucciniaceae. Uredia lacking; aecia present but without peridium; teliospores two-celled, one pore in each cell.

Arthuriomyces peckianus (formerly *Gymnoconia peckiana* (*G. interstitialis*). **Orange Rust** of blackberry. 0, I, III on blackberry, dewberry and black raspberry, first described from eastern United States in 1822, present from Canada to Florida and from Alaska to southern California. Very bright orange spores cover underside of leaves in spring. The mycelium is perennial in the bush, living throughout the year between cells of the stem, crown, and roots, each season invading new tissue as new growth begins. Shoots may be bunched, often with a witches' broom effect; plants are dwarfed. Spraying is useless; infected plants never recover. Plant only healthy stock, obtained from a nursery where the disease is unknown. Remove infected plants showing upright habit of growth, yellow color, and glistening yellowish dots of pycnia before the orange spore stage appears. Blackberry varieties Eldorado, Orange Evergreen, Russell, Snyder, Ebony King, dewberry *Leucretia*, and boysenberries are quite resistant.

Gymnoconia peckiana (**G. interstitialis**) (see *Arthuriomyces peckianus*).

Orange Rust of blackberry. 0, I, III on blackberry, dewberry and black raspberry, first described from eastern United States in 1822, present from Canada to Florida and from Alaska to southern California.

Gymnosporangium

Pucciniaceae. All but one species heteroecious. Picnia and aecia usually on trees and shrubs of the apple family; telia confined to cedars and junipers except for one species on cypress; uredia wanting. Teliospores thick- or thin-walled, various in form but mostly flat, tongue-shaped, expanding greatly when moistened, usually with two cells; walls smooth, one to several pores in each cell; pedicel colorless, usually with outer portion swelling and becoming jellylike when moistened. Aecia are highly differentiated and conspicuous, with catenulate aeciospores, deeply colored with verrucose walls (see Fig. 3.55).

The life cycle is similar in all juniper leaf rusts. In early summer, small, slightly swollen spots appear on leaves of the pomaceous host, then small raised specks in this area on the upper surface, openings of flask-shaped pycnia embedded in leaf tissue. After exuding an orange liquid containing pycniospores, the specks are black. Later, aecia push out on the underside of the same spots as dingy white columns, rostelia, with the outer coating rupturing to release a powdery mass of yellow to brown aeciospores. The ruptured segments sometimes make the open aecium look star-shaped, but in the common cedar-apple rust aecia are cup-shaped. Aecia are also formed on fruit and tender green stems. Aeciospores released during summer are wind-borne to junipers. Mycelium winters in the juniper needle or stem, and in spring galls are started that take a year or more to produce teliospores in cushions or horns.

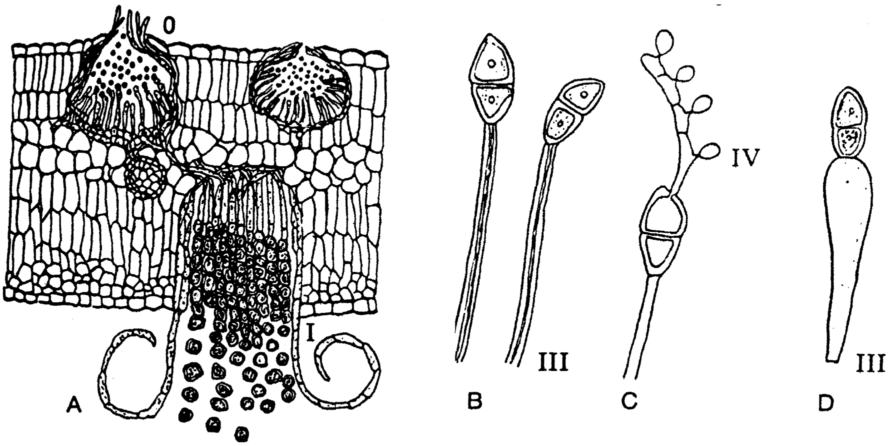


Figure 3.55 Cedar-Apple Rust. *Gymnosporangium juniperi-virginianae*. **A** section through crabapple leaf with pycnidia (*0*) on upper surface and aecium (*I*) with prominent peridium and aeciospores in chains on undersurface; **B** two-celled teliospores on gelatinous stalks, which help form the jellylike telial horns on cedar galls; **C**, teliospores germinating with a promycelium and basidiospores; **D** teliospore of *G. clavipes*, the quince rust

Gymnosporangium bermudianum. 0, I, III on stems of eastern and southern red-cedar in the Gulf states. No alternate host; aecia precede telia on small galls.

Gymnosporangium bethelii. III on Rocky Mountain juniper; 0, I on fruits of hawthorn.

Gymnosporangium bethelii. III on stems of prostrate and Rocky Mountain junipers; 0, I on leaves, fruit of hawthorn. Telia are 3 to 4 mm high on irregular galls on cedar twigs and branches.

Gymnosporangium biseptatum. III on stems of *Chamaecyparis thyoides*; 0, I on amelanchier. Spindle-shaped swelling in stem; trees may die.

Gymnosporangium clavariiforme. III on common and mountain juniper; 0, I on chokeberry, amelanchier, pear and quince. Slender telia 5 to 10 mm high produced on long fusiform swellings on branches.

Gymnosporangium clavipes. **Quince Rust**. III on eastern red-cedar, dwarf, mountain, and prostrate junipers; 0, I on fruits and young stems of amelanchier, apple, chokeberry, crabapple, hawthorn, mountain-ash, quince, Japanese quince and pear. Short slight swellings, somewhat spindle-shaped, occur in cedar twigs and branches, many of which die. On the main trunk, infected areas are black rough patches or rings around the bark. Mycelium is perennial, confined to the outer layer of living bark; it can sometimes be scraped out by scraping the bark. On pomaceous hosts, the disease is most frequent on fruits, often causing distortion. Rust sometimes affects twig and buds but seldom leaves. Aecia are particularly prominent on hips of English hawthorn, with long whitish perithecium around orange spores.

Control. Some apple varieties susceptible to apple rust are rather resistant to quince rust, including Jonathan, Rome, Ben, Davis, and Wealthy. Red Delicious is quite susceptible. Destroy cedars in neighborhood of orchards; spray as for apple rust.

Gymnosporangium confusum. III on Savin Juniper; 0, I on hawthorn.

Gymnosporangium cornutum (*G. auriantiacum*). **Juniper Gall Rust**. III on leaves and stems of common juniper; 0, I on mountain-ash.

Gymnosporangium cunninghamianum. III on Arizona cypress; 0, I on amelanchier.

Gymnosporangium davisii. III on mountain and common juniper; 0, I on leaves of red and black chokecherry. Telia are usually on upper surface of needles, sometimes at base of stems.

Gymnosporangium effusum. III on eastern red-cedar; 0, I on chokeberry. Fusiform swellings on cedar trunk and branches.

Gymnosporangium ellisii. **Witches' Broom Rust**. III on southern white cedar (*Chamaecyparis*); 0, I on sweet-fern, gale, bayberry, wax-myrtle leaves, fruits and young stems. Aecia are cluster cups; telia are cylindrical, filiform, 3 to 6 mm high, appearing on leaf blade or axil the first season after infection, thereafter only on stems, invading inner bark and wood. Witches' brooms are abundant; even large trees die if heavily broomed.

Gymnosporangium exiguum. III on leaves of alligator and Mexican junipers, eastern red-cedar; 0, I on leaves, fruits of hawthorn.

Gymnosporangium exterum. III on stems of eastern red-cedar; 0, I on gillenia. Flattened telia anastomose over short fusiform swellings with roughened bark on cedars. Also galls on stems of juniper.

Gymnosporangium floriforme. III on red-cedar; 0, I on leaves of hawthorn. Cedar galls are small.

Gymnosporangium fraternum (*G. transformans*). III gall on *Chamaecyparis thyoides*; 0, I on chokeberry.

Gymnosporangium globosum. **Hawthorn Rust**, III general on eastem red-cedar, also on dwarf, prostrate, and Rocky Mountain junipers; 0, I mostly on hawthorn, also on apple, crabapple, pear and mountain-ash. Leaf galls on cedar are very similar to those of common cedar-apple rust, but are smaller, seldom over 1/2 inch, nearer mahogany red in color, and not perennial, producing telial horns one season only. Apple and pear foliage may be slightly affected but not the fruit; aecia are common on hawthorn pips.

Gymnosporangium gracile. III **Witches' Broom** on juniper; 0, I on hawthorn, quince, and shadbush.

Gymnosporangium asiaticum. III on leaves of Chinese juniper; 0, I on Chinese flowering quince and pear.

Gymnosporangium harknessianum. III on western juniper; 0, I on amelanchier, chiefly on fruits, sometimes stems. Papery margins of aecia are usually long.

Gymnosporangium hyalinum. III on southern white-cedar; 0, I on hawthorn and pear leaves. Slight swellings are formed on small twigs and branches of white-cedar.

Gymnosporangium inconspicuum. III on Utah juniper; 0, I on fruits, mostly of amelanchier and squaw-apple. Juniper leaves turn yellow; rarely telia appear on branches.

Gymnosporangium japonicum (*G. photiniae*). III gall on stems of Chinese juniper; 0, I on photinia.

Gymnosporangium juniperi-virginianae. **Cedar-Apple Rust**. III general on red cedar, eastern and southern, on prostrate and Rocky Mountain junipers; 0, I general on apple and crabapple east of Great Plains. The fungus is a native of North America and does not occur elsewhere. It is more important commercially in the apple-growing regions of the Virginias and Carolinas and certain states in the Mississippi Valley. It is important in many areas on ornamental crabapples in home plantings.

The cedar "apples" or galls vary from 1/16 inch to over 2 inches across. Leaves are infected during the summer, and by the next June a small, greenish brown swelling appears on upper or inner leaf surface. This enlarges until by autumn the leaf has turned into a chocolate brown, somewhat kidney-shaped gall covered with small circular depressions. The next spring in moist weather orange telial horns are put forth from the pocketlike depressions. The teliospores are enveloped in a gelatinous material that swells vastly, a gall covered with horns sometimes reaching the size of a small orange. They germinate in place to produce the basidiospores, which are carried by wind to infect apple or other deciduous host.

By midsummer, apple leaves show yellow areas with amber pustules on upper surface; but after pycnia have exuded drops of sticky liquid,they appear as black dots in a rather reddish circle. On the undersurface of these spots small cups are formed, with recurved fimbriate margins. These aecia may also appear near stem end of apples and are common on swollen twigs of crabapple. Spores from these cups are blown back to the cedar in late summer, the entire cycle thus taking 2 years, 18 to 20 months on the cedar, 4 to 6 on the apple host.

Chief injury is to the apple host, the rust causing premature defoliation, dwarfing and poor-quality fruit. On very susceptible crabapples, such as Bechtel's crab, repeated infection may cause death of the branches or of the entire tree. All our native crabapples are susceptible; most Asiatic varieties are resistant.

Control. Care in planning is most important. Don't let your landscape architect or gardener put cedars and native crabapples or hawthorns close together. Keep them separated as far as possible with a windbreak in between of some tall nonsusceptible host. Some states have laws prohibiting red-cedars within a mile of commercial apple orchards, but for practical garden purposes a few hundred yards is sufficient, the danger markedly decreasing with distance, especially with a house or hedge as a windbreak.

If junipers are already planted, it is possible in late winter to go over small specimens and remove galls before spore horns are formed. Spraying in spring inhibits telial development and germination of teliospores. Spray red-cedars in August to prevent infection from crabapples.

Fairly resistant apple varieties are Baldwin, Delicious, Rhode Island and North-western Greening, Franklin, Melrose, Red Astrachan, Stayman, and Transparent. Avoid susceptible Jonathan, Rome, Wealthy, and York Imperial. Most junipers susceptible to apple rusts are cultivars of *Juniperus virginiana* and *J. scopulorum*. Many cultivars of *J. chinensis* and *J. horizontalis* are resistant, and there are even some resistant forms of *J. virginiana.*

Gymnosporangium kernianum. III on alligator, Utah, and western junipers; 0, I on amelanchier and pear. Telia arise between leaves on green twigs, but mycelium is perennial in stems, causing dense witches' brooms 6 to 18 inches in diameter.

Gymnosporangium libocedri. III on incense cedar; 0, I on leaves, fruits, of amelanchier and hawthorn, also apple, crabapple, pear, quince, Japanese quince and mountain-ash. Aecium is a cluster cup on foliage; telia are always on leaves; witches' brooms and swellings are produced on branches, rarely on trunks. The fungus is said to persist in the mycelial stage up to 200 years.

Gymnosporangium multiporum. III on stems of western, one -seed, and Utah juniper between leaves; 0, I unknown.

Gymnosporangium nelsonii. III on juniper and red-cedar; 0, I on leaves of amelanchier.

Gymnosporangium nelsonii. III on one-seed, prostrate, Rocky Mountain, Utah, and western junipers; 0, I on hawthorn, quince, Oregon crab, pear, squaw-apple and Pacific mountain-ash. Galls are firm, woody, round, up to 2 inches in diameter.

Gymnosporangium nidus-avis. **Witches' Broom Rust**. III on eastern and southern red-cedars, on prostrate and Rocky Mountain junipers; 0, I on fruit, young stems, leaves of apple, hawthorn, mountain-ash, quince, Japanese quince, amelanchier or serviceberry. Trunks and branches of large trees have witches' brooms and long spindle-shaped swellings. Aecia are on both leaf surfaces.

Gymnosporangium nootkatense. **Gall Rust**. II, III on Alaska cedar; 0, I on mountain-ash, and Oregon crabapple. This is the only *Gymnosporangium* species with uredial stage. Uredia are bright orange fading to pale yellow; teliospores appear later in the same pustules. Aecia are cluster cups.

Gymnosporangium speciosum. III on alligator, one-seed, and Utah junipers; 0,I on leaves of syringa (*Philadelphus*) and fendlera. Telia are in longitudinal rows on long fusiform swellings on juniper branches, which are girdled and die. In severe infections the whole tree dies.

Gymnosporangium trachysorum. III on stem of eastern red-cedar; 0, I on hawthorn leaves. Swellings on cedar are abruptly fusiform to globoid with prominent telia 6 to 10 mm high.

Gymnosporangium tremelloides (*G. juniperinum*). III, stem gall on mountain juniper; 0, 1 on Pacific mountain-ash. On smaller branches swellings are subglobose galls up to 3/4 inch in diameter; hemispherical swellings on larger branches are covered with flattened telia.

Gymnosporangium vauqueliniae. **Witches' Broom Rust**. III on one-seed juniper; 0, I on *Vauquelinia californica*. This rust is the only *Gymnosporangium* causing witches' brooms on the aecial host.

Hyalopsora

Melampsoraceae. Telia on ferns, teliospores several-celled, in epidemis; urediospores of two kinds, with pores.

Hyalopsora aspidiotus. **Fir-Fern Rust**. 0, I on balsam fir; II, III on oak fern

(*Phegopteris dryopteris*). Pycnia are slightly raised orange-yellow spots on needles; aecia are yellow to white, columnar, on 2-year needles.

Hyalopsora cheilanthis. **Fir-Fern Rust**. 0, I on balsam fir; II, III on rock brake, parsley fern, and cliff brake.

Hyalopsora polypodii. **Fir-Fern Rust**. General in northern and western states on polypody fern and woodsia.

Kuehneola

Puciniaceae. Teliospores two- to many-celled; wall faintly colored or colorless.

Kuehneola malvicola. II, III on hibiscus and malvaviscus.

Kuehneola uredinis. **Yellow Rust**, **Cane Rust**. 0, I, II, III on blackberry, dewberry, and raspberry. The disease appears to be increasingly prevalent, especially on leaves, but there is a great difference in varietal susceptibility. Eldorado, Foster,Jumbo, Lawton blackberries are highly susceptible; Nantichoke, Austin Thornless, Boysen Brainerd, Burbank Thornless, Jersey Black are resistant. European varieties are generally resistant.

Kunkelia

Pucciniaceae. Pycnia subcuticular; telia subepidemal, caeomoid; teliospores catenulate, one-celled.

Gymnoconia nitens (formerly *Kunkelia nitens*). **Short-Cycle Orange Rust** of blackberry. I, general on blackberry but more common in the South and West, also on dewberry and black,but not red raspberry. This is a perennial rust, a systemic disease with only the aecial stage present. Underside of leaves may be covered with quantities of orange-yellow spores. Remove infected bushes.

Kunkelia nitens (see *Gymnoconia nitens*). **Short-Cycle Orange Rust** of blackberry.

Melampsora

Melampsoraceae. Telia more or less indefinite; teliospores sessile, subcuticular or subepidermal, forming crusts of a single layer; aecia when present with rudimentary peridium; uredia erumpent, pulverulent; spores globoid or ellipsoid, single on pedicels.

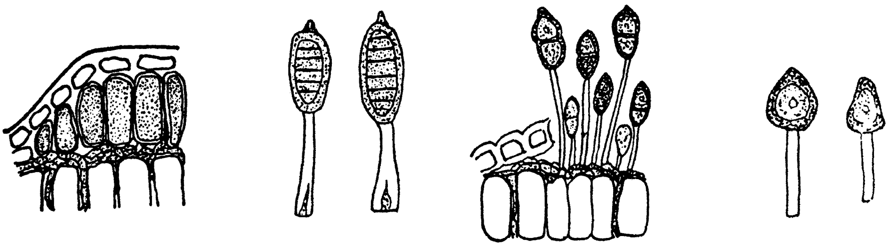


Figure 3.56 Teliospores. *Melampsora*, sessile in crust under host epidermis; *Phragmidium*, stalked, with several cells; *Puccinia*, stalked, two-celled; *Uromyces*, stalked, one-celled

Species heteroecious when telia are on woody plants; autoecious if telia are on herbaceous plants (Fig. 3.56).

Malampsora abieti-capraearum. **Fir-Willow Rust**. 0, I on balsam, white, and alpine firs; II, III on willows, widespread. Yellow spots on willow leaves in early summer are followed by dark pustules when the telial stage is produced. There may be some defoliation.

Melampsora abietis-canadensis. **Hemlock-Poplar Rust**. 0, I on eastern hemlock; II, III on various poplars. Cones have golden powdery masses of spores over the surface; later shrivel, turn black, and hang as mummies; no viable seed produced. Uredia are golden powdery pustules on undersurface of poplar leaves; in late summer telia are formed in orange-yellow crusts that change to black; in spring basidiospores reinfect hemlock.

Melampsora arctica. 0, I on saxifrage; II, III on willow.

Melampsora farlowii. **Needle And Cone Rust** of hemlock. 0, I unknown; III on hemlock. Reddish slightly raised telia are on undersurface of needles, shoots of the current year, and on cones. Young shoots may be twisted and killed. Injury may occur in nurseries and in ornamental hedges.

Melampsora hypericorum (*Mesopsora hypericorum*). On St. Johnswort, Montana.

Melampsora larici-populina. **Rust**; 0, I, on pine and larch; II, III, on poplar.

Melampsora medusae. **Douglas-Fir Needle Rust**. 0, I on Douglas-fir, big-cone spruce; II, III on native poplars. Pycnia are on upper surface of current-year needles; aecia, of the caeoma type, are orange-yellow on the undersurface. The rust is often epidemic on young trees but with little permanent ill effect.

Melampsora medusae. **Larch Needle Rust**. 0, I on larch in northeastern states; II, III on native and introduced poplars except in far South.

Melampsora medusae f. sp. **deltoidae**. **Rust**; 0, I on Douglas fir, pine and larch; II, III, on poplar.

Melampsora occidentalis. **Poplar Rust**. 0, I unknown; II, III on native poplars in the West.

Melampsora paradoxa (*M. bigelowii*). **Larch-Willow Rust**. 0, I on larch; II, III on many species of willow. The damage to larch is insignificant. The fungus winters on willow as mycelium in catkins, terminal buds, and young stems and can maintain itself on willow in the uredial stage without larches.

Melampsora ribesii-purpureae. 0, I on currant, flowering currant and gooseberry; II, III on willow species.

Melampsorella

Melampsoraceae. Heteroecious on fir, spruce, and dicotyledons; pycnia subcuticular, aecia and uredia subepidermal, telia in epidemal cells. Only one species in United States.

Melampsorella caryophyllacearum (*M. cerastii*). **Yellow Witches' Broom Rust**. 0, I on many firs; II, III on chickweed. Infected evergreen branches develop numerous upright lateral shoots from one point, forming a compact witches' broom; twigs are dwarfed, and needles turn yellow and drop, leaving brooms bare. The fungus is perennial in stems, and shoots develop with yellow leaves. Pycnia appear in raised orange spots on both surfaces of dwarfed leaves in spring; aecia form in summer on underside, in two rows of orange blisters. The disease is seldom serious enough for control measures. In forest practice remove trees with main stem infections early in life of the stand.

Melampsoridium

Melampsoraceae. Heteroecious, on larch and dicotyledonous shrubs and trees; pycnia subcuticular; other sori subepidermal; teliospores sessile, one-celled.

Melampsoridium betulinum. **Birch Leaf Rust**. 0, I on larch; II, III on birches. Uredia on underside of birch leaves are small reddish yellow powdery pustules, followed later in summer by telia, first waxy yellow, then dark brown to nearly black.

Milesina

Melampsoraceae. Heteroecious on firs and ferns. All spores are colorless; urediospores obovate or laceolate; teliospores in epidemal cells.

Milesina fructuosa. 0, I on balsam fir; II, III on *Dryopteris* spp. Aecia are white on current needles, maturing by midsummer.

Milesina laeviuscula. **Needle Rust**. 0, I on grand fir; II, III on licorice fern, in West.

Milesina marginalis. 0, I on balsam fir; II, III on *Dryopteris marginalis*. Pycnia are on both sides of needles, aecia of needles of current year, maturing by midsummer.

Milesina pycnograndis (*M. polypodophila*). 0, I on balsam fir; II, III on *Polypodium virginianum*. Hyphae are perennial in needles and small stems of balsam fir; aecia on needles 3 to 9 years old.

Nyssopsora

Puccinaceae. Autoecious; teliospore with three cells.

Nyssopsora clavellosa. III on *Aralia hispida*.

Peridermium

A form genus with 0, I, on Gymnosperms. Aecia have peridia and are cylindrical, tonguelike or bullate.

Peridermium bethelii. On dwarf mistletoe.

Peridermium ornamentale. 0, I on white, alpine, and noble firs.

Peridermium rugosum. 0, I on Pacific silver and lowland white firs.

Phakopsora

Melampsoraceae. Telia indehiscent, lenticular; spores formed in irregular succession, not in chains.

Phakopsora cherimoliae. On cherimoya.

Phakopsora jatrophicola. On cassava.

Phakopsora pachyrhizi. On soybean.
Phakopsora zizyphi-vulgaris. On *Zizyphus jujuba*, Florida.

Phragmidium

Pucciniaceae. Autoecious. Pycnia subcuticular, other sori subepidermal; aecia caeomoid; teliospores large, conspicuous, of one to ten or more cells, each with two or three lateral pores; walls somewhat layered, inner layer colored, outer nearly colorless, smooth or verrucose; pedicel colorless except near spore; often swelling in lower portion (see Fig. 3.56). Aecia with catenulate globoid or ellipsoid verrucose spores; uredia when present circled with paraphyses; urediospores single on pedicels, walls verrucose or echinulate with indistinct scattered pores.

Phragmidium americanum. 0, I, II, III on leaves of native and cultivated roses. Teliospores with eight to eleven cells.
Phragmidium fusiforme (*P. rosae-acicularis*). 0, I, II, III on several hosts species. Teliospores with five to eleven cells, walls chocolate brown, verrucose.
Phragmidium montivagum. 0, I, II, III on many species of roses. Teliospores with six to nine cells.
Phragmidium mucronatum (*P. disciflorum*). **Leaf Rust of Rose**. 0, I on leaves and stems; II, III on leaves of cultivated roses, eastern states to the Rocky Mountains and on the Pacific Coast. This is the common rust of hybrid teas and other roses with large, firm leaflets. It is not much of a problem in the East, although sometimes found in New York and New England gardens, but it is a serious menace along the Pacific Coast. Aecia appear on leaves as small, roughly circular spots, 1/25 inch across, bright orange on the underside of leaf, from the spore masses, light yellow on the upper surface, sometimes bordered with a narrow green zone. Leaf lesions may be slightly cup-shaped viewed from the upper surface. Stem lesions are long and narrow. The summer uredial stage has reddish orange spores in very small spots, 1/50-inch, over underside of leaves. This stage may repeat every 10 to 14 days in favorable weather, with wilting and defoliation. In mild climates the uredial stage continues; in cooler areas the telial stage is formed toward autumn – black pustules of stalked dark spores, rough, with a point, five to nine cells.
The leaf surface must be continuously wet for 4 hours for rust spores to germinate and enter the leaf; this means liquid water and not high humidity as with mildews. High summer temperatures adversely affect infection,

summer spores retaining viability for only a week at 80°F. In southern California temperatures are uniformly favorable for rose rust, and from October to April there is sufficient rainfall. In drier months fog may provide requisite moisture.

Control. Removing infected leaves during the season and all old leaves left at the time of winter or early spring pruning may be somewhat helpful.

Phragmidium rosae-arkansanae. 0, I, II, III on *Rosa arkansana* and *R. suffulta*. Teliospores with five to eight cells.

Phragmidium rosae-californicae. 0, I, II, III on many rose species. Teliospores with eight to eleven cells.

Phragmidium rosicola. III on *Rosa engelmanii* and *R. suffulta*. Teliospores one-celled, nearly round.

Phragmidium rubi-idaei. **Leaf and Cane Rust** of raspberry; **Western Yellow Rust**, general but important only in the Pacific Northwest. 0, I, II, III on red rasberries, sometimes black but not on blackberries. Small, light yellow spore pustules appear in young leaves, with black teliospores following in the same spots later in the season. Deep, cankerous lesions are formed on canes in the fruiting year, Cuthbert variety being particularly susceptible. Spring infection probably comes from sporidia formed in telia on fallen leaves. A dormant spray may be helpful, along with cleaning out infected canes at winter pruning.

Phragmidium speciosum. 0, I on stems and leaves, III on stems of cultivated and native roses, throughout United States except far South.

Phragmidium subcorticium. Obsolete name. Some specimens formerly recorded as this species belong to *P. mucronatum*, others to *P. rosae-pimpinellifoliae*.

Phragmidium tuberculatum. On *Rosa* sp. Connecticut and Alaska.

Phragmopyxis

Pucciniaceae. Teliospores colored, two- to many-septate; wall three-layered, the middle layer swelling in water; aecia, uredia, and telia with a border of paraphyses.

Phragmopyxis acuminata. 0, III on *Coursetia*.

Physopella (Angiopsora)

Pucciniaceae. Only uredia and telia known. Telia indehiscent, lenticular; teliospores in chains.

Physopella ampelopsidis (*Phakopsora vitis*). On ampelopsis and grape, Florida.
Physopella compressa. On paspalum, southern ornamental grass.

Pileolaria

Pucciniaceae. Autoecious, on members of family Anacardiaceae. Teliospores stipitate, dark, with pores, one-celled; pycnia subcuticular; uredia present.

Pileolaria cotini-coggyriae. On smoke tree.
Pileolaria patzcuarensis. 0, I, II, III on sumac.

Prospodium

Pucciniaceae. Autoecious on Bignoniaceae and Verbenaceae in warm climates.

Prospodium appendiculatum. On tecoma, Florida, Texas.
Prospodium lippiae. On lippiae, Arizona.
Prospodium plagiopus. On tabebuia, Florida.
Prospodium transformans. On tecoma, Florida.

Puccinia

Pucciniaceae. A very large genus, comprising nearly half of all known rusts; autoecious and heteroecious. Teliospores smooth, two-celled with apical pores, firm pedicels, colored; aecia cluster cups with peridium (see Fig. 3.56). The species listed here are a small selection of those on garden plants; others are listed in host section.

Puccinia acroptili. **Rust** on *Centaurea*.
Puccinia allii (*P. porri*). Autoecious on onion, garlic and shallot, but 0, I stages rare. Occasional on cultivated onion, more common on garlic, wild garlic, and wild onion. Uredia are yellowish, telia black.
Puccinia amphigena (*Aecidium yuccae*). On yucca.
Puccinia andropogonis, with various strains. 0, I on lupine, Indian paintbrush and turtlehead; II, III on andropogon.
Puccinia antirrhini. **Snapdragon Rust**. II, III general on snapdragon, also on linaria, corydylanthus; 0, I unknown. Pustules of spores on underside of leaves are chocolate brown, often in concentric circles (see Fig. 3.57). The

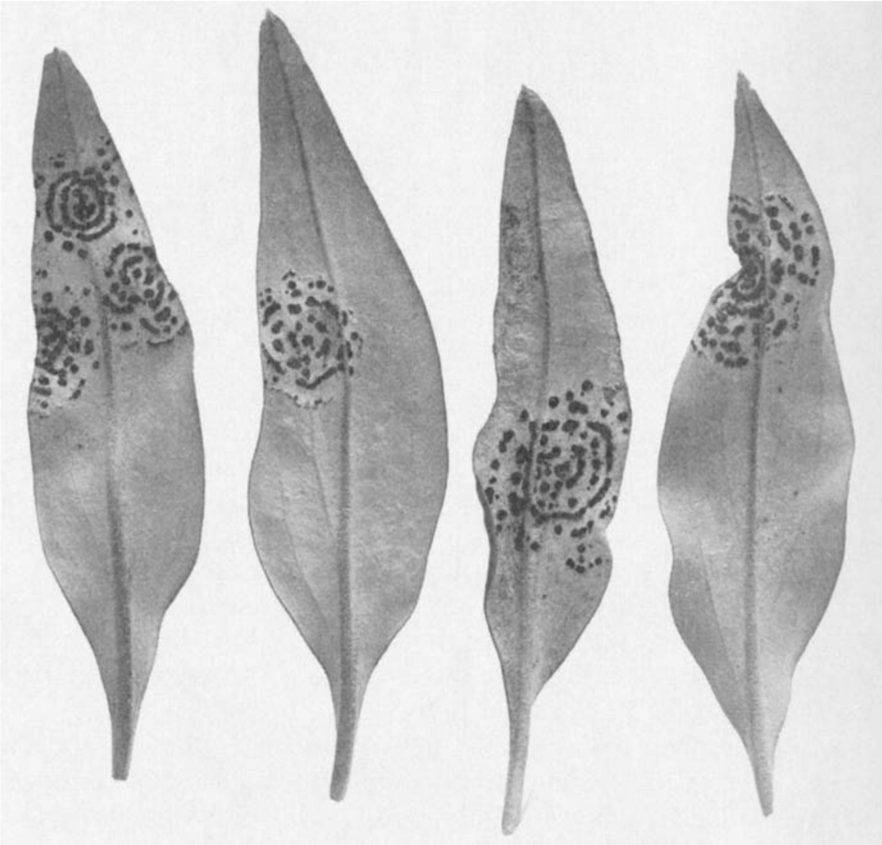


Figure 3.57 Rust on Snapdragon

area over the pustule is pale or yellow on upper surface. Spores also appear on stems; there is a drying and stunting of whole plant. The rust is spread by wind-blown spores and on cuttings. For infection, plants need to be wet with rain or dew 6 to 8 hours with day temperatures around 70° to 75°F. Spores are killed above 94°F. There are at least two races.

Control. Purchase only rust-resistant variety. Bordeaux mixture controls secondary fungi following rust but not the rust itself. Sulfur dust is still useful, or a spray made by adding 1 ounce rosin soap to a gallon of water and then adding 1 ounce dry lime sulfur.

Puccinia arachidis. **Peanut Rust**, occasional in Alabama, Florida, Texas.

Puccinia aristidae and varieties. II, III on wild grasses, *Aristides* and *Distichlis*; 0, I on eriogonum, greasewood, beet, spinach, western wallflower, garden cress, radish, California bluebell, heliotrope, cleome, primrose, sand-verbena, and others.

Puccinia asparagi. **Asparagus Rust**. II, III general on susceptible varieties; 0, I not reported in natural infections. Also on onion. Asparagus rust reached America in 1896 from Europe and spread with devastating suddenness from Boston and New Jersey to California, reaching there by 1912, one of the fastest cases of disease spread in our history. If tops are attacked several years in succession, the root system is so weakened that shoots fail to appear in spring or are culls.

The first symptom is a browning or reddening of smaller twigs and needles, with the discolored area spreading rapidly until the whole planting looks as if it had ripened prematurely. The reddish color is due to numerous small pustules of urediospores that give off a dusty cloud when touched. These appear in successive generations until autumn, or a spell of drought, when they are replaced by black teliospores, either in the same or a new fruiting body. They remain on old stems until spring, germinating then to infect new shoots as they emerge from the ground.

Control. For a long time resistant varieties Mary Washington and Martha Washington were the answer to the rust problem, but the fungus has developed resistant strains. Waltham Washington, Seneca Washington, and California 500 have some resistance. Clean up volunteer or wild asparagus around beds. A parasitic fungus, *Darluca filum*, helps keep rust in check.

Puccinia brachypodii var. **poae-nemoralis** (formerly *Puccinia poae-nemoralis* (Syn. *P. poae-sudeticae*)). **Bluegrass Leaf Rust**, **Yellow Leaf Rust**. II, III on turf grasses, mostly Canada and Kentucky bluegrass; 0, I, unknown; general east of the Rocky Mountains. The uredia are orange-yellow with numerous peripheral paraphyses. Telia are covered rather permanently with epidermis; spores are dark brown with short pedicels. The wheat stem rust is more important on Merion bluegrass.

Puccinia calcitrapae var. **centaureae** (formerly *Puccinia carthami*). Widely distributed on safflower in Great Plains and California. Spores carried on seed or persisting in soil infect seedlings, which often die.

Puccinia canaliculata. **Rust** on purple nutsedge and yellow nutsedge.

Puccinia carduorum. **Rust** on *Carduss tenniflorus* and *Carduss thoermeri*.

Puccinia caricina (*P. caricis* var. *grossulariata, P. pringsheimia*). 0, I on currant, flowering currant, gooseberry; II, III on *Carex* spp. Common only on wild species or in neglected gardens. Leaves are thickened, sometimes curled in reddish cluster cup areas; there are enlargements on stems and petioles, red spots on berries. Control by eliminating the sedge host.

Puccinia carthami (see *Puccinia calcitrapae* var. *centaureae*). Widely distributed on safflower in Great Plains and California.

Puccinia claytoniicola. On claytonia, Wyoming.

Puccinia conoclinii. On ageratum, Ohio.

Puccinia coronata. **Crown Rust** of oats; Orange Leaf Rust of Oats. 0, I on buckthorn and rattan vine; II, III on oats and grasses. There are several varieties and many physiological races of this rust, which is as destructive to oats as leaf rust is to wheat. Redtop, meadow fescue, ryegrass, and bluegrass are among the lawn grasses that may show orange or black pustules on leaves.

Puccinia crandallii. 0, I on snowberry, wolfberry, coralberry; II, III on grasses, fescues, bluegrass.

Puccinia cynodontis. On Bermuda grass, New Mexico.

Puccinia cypripedii. On orchids.

Puccinia dioicae (*P. extensicola*) in many varieties. 0, I on aster, goldenrod, erigeron, senecio, lettuce, oenothera, rudbeckia, and helenium; II, III on *Carex* spp.

Puccinia dracunculi (see *Puccinia tanaceti* var. *dracunculina*). On artemisia, Wisconsin to the Pacific Coast.

Puccinia flaveriae (see *Puccinia melampodii*). On *Calendula*.

Puccinia graminis. **Stem Rust** of grains and grasses. 0, I on barberry and mahonia, especially in north central and northeastern states; II, III on wheat and other cereals and wild and cultivated grasses.

This is the classic example of rust, the one used in school textbooks and known through the ages as the major limiting factor of wheat production. Proof of the connection between barberry and wheat in the life cycle was not made until 1864, but long before that farmers had noticed that wheat suffered when barberry plants were near. France in 1660, Connecticut in 1726, and Massachusetts in 1755 enacted laws requiring the destruction of barberry near grain fields.

There are six commonly recognized varieties of stem rust:

Puccinia graminis f. sp. *avenae*– on oats, sweet vernal grass, brome grasses, some fescues.

P. graminis f. sp. *agrostidis*– on redtop and other *Agrostis* spp.

P. graminis f. sp. *graminicola*—on St. Augustine grass.

P. graminis f. sp. *phlei-pratensis*– on timothy and some related grasses.

P. graminis f. sp. *poae*– on Kentucky and other bluegrasses.
P. graminis f. sp. *secalis*– on rye, some wheat, and barley grasses.
P. graminis f. sp. *tritici*, wheat rust – on wheat, barley, rye, and many grasses. Stem rust occurs wherever wheat is grown, but is most serious in northern states. It is dependent on weather conditions, with epidemics and disastrous losses in certain seasons. The amount depends on the maturity of the crop when rust strikes, but losses may run 25% of expected yield for the nation and much higher for individual states. There are a great many physiological races.
On grains and grasses the first rust appears as long, narrow streaks on stems, leaf sheaths, leaf bases, and distal portions of blades. These streaks are uredial sori, the epidermis being torn back to form a white collar around a dark red powdery mass of one-celled urediospores. Later the same sori turn black as dark, two-celled teliospores replace summer urediospores. Stems may be broken at this stage.
The summer spores appear about 10 days after infection. This stage can be repeated, the spores reinfecting wheat, and, since they are carried by wind from one plant to another, one state to another, even to hundreds of miles, they account for large outbreaks of disease. In Mexico and southern Texas this II stage continues through the winter and causes spring infection without the intervention of barberry. Waves of urediospores coming up from the South may start northern infection.
Normally in the North, spring infection starts on barberry from sporidia (basidiospores) produced on a promycelium put forth by a teliospore wintered on a wheat stem. Two sexes occur in this rust, designated + and – rather than male and female. A young teliospore contains two nuclei, one + and the other –; as the spore matures, these fuse to a single nucleus, which divides twice in the production of the four-celled basidium (promycelium). Each cell produces a sporidium; two of these are + and two –. A sporidium falling on a barberry leaf germinates, sends in an infection thread, and develops a mononucleate (haploid) feeding mycelium and finally a flask-shaped pycnium containing pycniospores, which correspond to the sex of the sporidium starting infection. The pycnia are in reddish lesions on the upper leaf surface. Hyphal threads, receptive hyphae, extend through the mouth of the pycnium. Aided by insects, which are attracted by a sweet nectar, pycniospores (spermatia) of one sex are brought into contact with receptive hyphae of the opposite sex, and sexual union takes place, without which there is no further development of the rust.

The dicaryotic or binucleate mycelium formed from the fertilized hypha grows through the cells of the barberry leaf and masses together on the underside to produce aecia filled with a yellowish waxy layer of aeciospores in cluster-cup formation. These spores, unable to reinfect barberry or mahonia are wind-borne to the cereal or grass host, the subsequent mycelium continuing binucleate until the fusion in the teliospore. New crops of urediospores can be produced every 10 to 14 days.

Control. Resistant varieties are of primary importance, but they are difficult to maintain because the sexual process in rusts allows the continuous development of new strains. More than 200 strains are known, but only a dozen or so are important in any one year. Race 15B is prevalent most years and can attack all varieties of wheat grown in this country. Eradication of the barberry eliminates the alternate host and also the breeding place of new rust varieties. Most barberry and mahonia species are under quarantine, but some have been designated rust-resistant by the U.S. Department of Agriculture and may be shipped interstate under permit.

Puccinia helianthi. **Sunflower Rust**. 0, I, II, III general on sunflower, Jerusalem artichoke, and heliopsis. Numerous brownish pustules in which repeating spores are formed develop on underside of leaves, which may dry and drop.

Puccinia heterospora. III on abutilon, hollyhock, mallow, and malvaviscus.

Puccinia heucherae. III on coral bells, woodland star, saxifrage, bishops-cap, and foam-flower.

Puccinia hieracii. 0, I, II, III widespread on endive and hawksbeard. Endive leaves are spotted and blighted with dusty spore pustules. The crop is occasionally lost, but no control has seemed practical.

Puccinia horiana. **White Rust**. III, IV on chrysanthemum; no alternate host known. First reported in England in 1964; became widespread there in 1976. Found in amateur chrysanthemum plantings in New Jersey and Pennsylvania in 1977.

Puccinia iridis. **Iris Rust**. 0, I, II, III on bulbous iris, serious in the Southeast, uncommon in Northwest. Small, oblong to oval, red or dark brown powdery spots, often surrounded by a yellow margin, are present on leaves and stems, which may die prematurely. In inoculation tests with Dutch iris, varieties Early Blue, Gold and Silver, Golden West, Imperator, Lemon Queen, and Texas Gold were resistant.

Puccinia jaceae var. **diffusa**. **Rust** on *Centaurea*.

Puccinia lagenophorae. On English daisy.

Puccinia malvacearum. **Hollyhock Rust**. III general on hollyhock, also on mallow, and lavatera. This rust is so common and destructive it limits the use of hollyhocks as ornamentals. Stems, leaves, bracts may be attacked. There are yellow areas on the upper surface of leaves, orange-red spore pustules on the underside, and elongated lesions on stems. Spore pustules are sometimes grayish from formation of sporidia, but the alternate host is unknown. In severe infections leaves dry and hang down along the stem. The fungus winters in pustules in basal leaves and in old stems.

Control. Cleaning up all infected plant parts in fall and again very early in spring is most important; infection starts early in the season, and once it is under way, it is very difficult to curb with a fungicide.

Puccinia melampodii (formerly *Puccinia flaveriae*). On *Calendula*.

Puccinia melampodii. On *Baccharis*, Texas.

Puccinia menthae. **Spearmint Rust**. 0, I, II, III on spearmint, peppermint, oregano, also horse-mint, mountain-mint, dittany, bee-balm, yerba buena, and germander; especially serious for mint farmers in Middle West and Northwest. In spring and early summer the disease appears as light yellow to brown raised spots on deformed stems and leafstalks, sometimes on main veins; golden to chocolate brown spots appear in late summer and fall. Affected leaves dry, and the yield of oil is reduced. The pathogen has at least 10 races. Dusting with sulfur and early cutting are recommended.

Puccinia nakanishikii. **Rust** on lemon grass.

Puccinia pelargonii-zonalis. **Pelargonium Rust**. The uredinial stage of a rust, presumably this species, was found on geranium in New York and California in 1967. It has now been reported in Pennsylvania and Florida. Brown spore pustules appear on leaves, petioles, and stems; leaves turn yellow and drop. Destroy infected plants.

Puccinia phragmitis. 0, I on rhubarb; II, III on reed grass, sometimes present in California but not serious. Aecia are white, on underside of rhubarb leaves, surrounded by pycnia.

Puccinia poae-nemoralis (Syn. **P. poae-sudeticae**) (see *Puccinia brachypodii* var. *poae-nemoralis*). **Bluegrass Leaf Rust**, **Yellow Leaf Rust**. II, III on turf grasses, mostly Canada and Kentucky bluegrass; 0, I, unknown; general east of the Rocky Mountains.

Puccinia polygoni-amphibii. Rust; II, III, on jointweed.

Puccinia polysora. **Southern Corn Rust**. 0, I, unknown; II, III on corn and grasses. Present in the South, requiring higher temperatures than common corn rust; not very important. Urediospores are yellow to golden, teliospores chestnut brown, angular; often parasitized by *Darluca filum*.

Puccinia psidii. **Rust** on allspice (*Pimenta dioica*) *Melaleuca quinquenervia*, and *Syzygium jambos*.

Puccinia pygmaea. **Rust** on grasses.

Puccinia recondita (*P. rubigo-vera*). **Leaf Rust** of cereals and grasses, with several varieties:

P. recondita tritici (*P. triticina*). II, III on wheat (but not grasses); 0, I on meadow rue. This rust is worldwide and more serious than stem rust in the southern half of the American wheat belt, sometimes epiphytotic with losses up to 30%. The leaf tissue is progressively destroyed through the season, resulting in a reduced number of kernels, shriveled grain, low weight and protein content. Rust pustules breaking through the epidermis greatly increase transpiration losses. Orange uredial pustules are followed later by gray telial sori, but urediospores are the effective spore form and can survive southern winters. There are many physiological races.

P. recondita agropyri. II, III on wheat grasses and wild ryegrasses; 0, I on clematis, buttercup, columbine, larkspur, and other Ranuculaceae. Common in Rocky Mountain area.

P. recondita agropyrina. Similar to the above but occurring outside mountainous areas.

P. recondita apocrypta. II, III on wheat and wild grasses; 0, I on waterleaf and mertensia.

P. recondita impatientis. II, III on redtop and related grasses; 0, I on touch-me-not.

P. recondita secalis. II, III on rye; 0, I on bugloss (*Lycopsis*).

Puccinia solheimi. On dodocatheon, Wyoming.

Puccinia sorghi. **Corn Rust**. 0, I on oxalis; II, III on corn, sweetcorn, general in northeastern and north central states. Cinnamon brown spore pustules cover both leaf surfaces with black pustules toward autumn. The disease is not often serious enough for control measures.

Puccinia sparganioides (*P. peridermiospora*). **Ash Rust**. 0, I, general on ash east of the Great Plains; II, III on marsh and cord grasses (*Spartina* spp.). Ash twigs and petioles are swollen and leaves distorted. Cluster cups filled with yellow powdery aeciospores are formed in the swellings. In New England, where rust is often severe, the most important infection period on ash is May 15 to June 20, with 6 to 8 hours of damp air necessary. Marsh grasses are infected and reinfected July 20 to August 20.

Puccinia stenotaphricola. On St. Augustine grass, Florida.

Puccinia striiformis (*P. glumarum*). **Stripe Rust** of wheat. II, III on wheat, barley, rye, redtop, orchardgrass, and many other grasses. Uredial stage is yellow, and pustules are formed in streaklike clusters on leaves; telia are in black streaks.

Puccinia substriata. **Rust** on eggplant.

Puccinia taneceti. **Chrysanthemum Rust**. II general; III known only in Japan; 0, I unknown. Small blisters of pinhead size appear on underside of leaves and occasionally on upper surface. The spore mass is dark reddish brown and powdery. The rust is more common in greenhouses than outdoors. Optimum germination is at 60° to 70°F; spores are killed at high temperatures.

Puccinia tanaceti var. **dracunculina** (formerly *Puccinia dracunculi*). On artemisia, Wisconsin to the Pacific Coast.

Puccinia thaliae (*P. cannae*). II, III on edible canna, garden canna,and maranta.

Pucciniastrum

Melampsoraceae. Heteroecious with perennial mycelium, pycnia and aecia on conifers: firs and spruces; pycnia subcuticular, other sori subepidermal; telia may be intraepidermal; aecia and urediospores yellow.

Pucciniastrum americanum. **Late Leaf Rust** of raspberry. 0, I on white spruce; II, III on red raspberry, not black. This rust appears late in the season on Cuthbert and other susceptible varieties, in northern half of the country, most common east of the Mississippi. Fine light yellow powdery masses of spores appear on basal leaves, leaf petioles, shoots, and even fruit.

Pucciniastrum epilobii. **Fuchsia Rust**, the alternate hosts are species of Abies.

Pucciniastrum goeppertianum. **Fir-Huckleberry Rust**, **Blueberry Witches' Broom**. 0, I on firs; III on low and high bush blueberries. The fungus is systemic and perennial in blueberries, producing short swollen twigs in a witches' broom effect, and telia forming a polished red layer around the shoots. Destroy diseased bushes; keep blueberry plantations some distance from firs.

Pucciniastrum hydrangeae. 0, I on eastern and Carolina hemlock; II, III on hydrangea.

Pucciniastrum vaccinii (*P. myrtilli*). **Hemlock Rust**, **Leaf Rust** of blueberry; widespread. 0, I on eastern hemlock; II, III on azalea, blueberry, cranberry, lyonia, menziesia, and rhododendron. This is the most common hemlock rust, but often only a single leaf or twig is infected. Aecia are formed on current-year needles. Blueberries have yellow pustules, on leaves only, with defoliation in mid- or late summer.

Ravenelia

Pucciniaceae. Autoecious, tropical with only a few species in United States. Teliospores more or less muriform, with compound stalks.

Ravenelia dysocarpae (see *Ravenelia fragrans* var. *evernia*). On *Mimosa*, Arizona.
Ravenelia fragrans var. **evernia** (formerly *Ravenelia dysocarpae*). On *Mimosa*, Arizona.
Ravenelia humphreyana. On *Poinciana*, Florida, Texas.
Ravenelia indigoferae. On *Indigofera*, Arizona.

Maravalia (Scopella)

Pucciniaceae. Tropical. Uredia and telia subepidermal. Teliospores one-celled, on pedicel.

Maravalia sapotae (formerly *Scopella sapotae*, Syn. *Uredo sapotae*). On sapodilla in Florida, infecting leaves in winter and early spring.
Scopella sapotae, Syn. **Uredo sapotae** (see *Maravalia sapotae*). On sapodilla in Florida, infecting leaves in winter and early spring.

Sphenospora

Pucciniaceae. Tropical. Telia and peridia subepidermal, then erumpent; teliospores waxy, two-celled, on pedicel.

Sphenospora mera. On bletilla, Florida.

Sphaerophragmium

Pucciniaceae. Teliospores stalked, four- to several-celled, with transverse and horizontal septa; on legumes.

Sphaerophragmium acaciae. On lebbek, Florida.

Tranzschelia

Pucciniaceae. Teliospores two-celled, stalked; uredia with pseudoparaphyses; on Ranunculaceae and *Prunus*.

Tranzschelia discolor (*T. pruni-spinosae* var. *discolor*). **Rust** of stone fruits. **Peach Rust**. 0, I on *Anemone coronaria*; II, III on apricot, peach, plum, prune, almond, and cherry, in late summer. Yellow angular spots appear on leaves with powdery spore pustules on underside, reddish on peach, dark brown on almonds; sometimes with late season defoliation. Peach fruit may have round sunken green spots; twigs may have oval blisters in early spring. Urediospores wintering on sucker shoots can start spring infection without the alternate host. The Drake variety of almond is most susceptible.
Tranzschelia pruni-spinosae var. **typica**. 0, I on anemone, hepatica, thalictrum, and buttercup; II, III on wild species of *Prunus*.

Triphragmium

Pucciniaceae. Teliospores stalked, with three cells forming a triangle, each with a single pore.

Triphragmium ulmariae. 0, I, II, III on meadowsweet.

Uredinopsis

Melampsoraceae. Telia on ferns; teliospores scattered irregularly in mesophyll, rarely in subepidermal crust, typically several-celled; aecia white.

Uredinopsis osmundae. **Fir-Fern Rust**. 0, I on balsam fir, widespread; II, III on *Osmunda* spp.

Uredinopsis phegopteridis. **Fir-Fern Rust**. 0, I on balsam fir; II, III on *Phegopteris dryopteris*.

Uredinopsis pteridis (*U. macrosperma*). **Fir-Fern Rust**. 0, I on various firs; II, III on *Pteridium aquilinum*. Aecia are on 1- to 5-year needles of Pacific silver, white, lowland white, alpine, and noble firs.

Uredinopsis struthiopteridis. **Fir-Fern Rust**. 0, I on balsam, lowland white, alpine, and noble firs; II, III on ostrich fern.

Uredo

Form genus; uredia with or without peridia.

Uredo artocarpi. Breadfruit in Hawaii.
Uredo coccolobae. On sea-grape, Florida.
Uredo ericae (*Pucciniastrum ericae*). On erica, California.
Uredo phoradendri. On mistletoe.

Uromyces

Pucciniaceae. Like *Puccinia* but teliospores with one cell, yellow to dark; aecia when present with a persistent peridium (see Fig. 3.56).

Uromyces appendiculatus. **Bean Rust**. 0, I rare on bean; II, III general on dry beans, widespread but infrequent on lima bean, scarlet runner bean. This is the true bean rust, an old disease reported as far back as 1798 and quite distinct from anthracnose that is sometimes called rust. It is particularly serious and prevalent on Kentucky Wonder pole beans.

Small rust pustules are formed on leaves most frequently, sometimes on stems and pods. The reddish brown sori are most numerous on underside of leaves, with the upper surface yellowing in the same areas. There may be nearly complete defoliation. In late summer in the North, dark telia replace summer spores, but in the South, urediospores survive the winter and start early spring infection. Rust spores are spread by wind and on tools and clothing. Some even cling to supporting poles and can start a fresh outbreak of rust if poles are not disinfested before reuse.

Control. No bean variety is resistant to all of the more than 30 races so far identified. Most snapbeans are highly tolerant of rust; and pole beans White

Kentucky Wonder, U.S. 4 Kentucky Wonder, Potomac, and Rialto are fairly tolerant.

Uromyces appendiculatus var. **appendiculatus** (Syn. *U. phaseoli*). **Rust** on bean.

Uromyces ari-triphylli. On jack-in-the-pulpit; Autoecious, O, I, II, III stages (entire ife cycle) on one host.

Uromyces betae. **Beet Rust**. II, III on beets, and swiss chard, in California, Oregon, occasionally Arizona and New Mexico. Reddish brown pustules may be numerous on foliage in late summer or in wet seasons. Control is seldom attempted for table beets; some sugar beet varieties are resistant. The seed-borne fungus also persists in volunteer plants and debris.

Uromyces ciceris-arietini. **Rust** on chickpea.

Uromyces costaricensis. **Rust** on wild bamboo.

Uromyces dianthi (*U. caryophyllinus*). **Carnation Rust**. 0, I on euphorbia (but not in United States); II, III general on carnation and sweet william, a serious disease under glass. Chocolate brown pustules, varying from 1/16 to 1/4 inch, break out on both sides of leaves and on buds and stems. Leaves curl up, often die; infected plants are stunted.

Control. Use surface watering where possible, avoiding syringing; keep greenhouses properly ventilated; use rust-free cuttings.

Uromyces fabae. **Pea Rust**. 0, I, II, III on pea, peavine, occasionally on broad bean; not very serious.

Uromyces galii-californici. On galium, California.

Uromyces punctatus. **Rust** on *Astragulus* in ID and OR.

Uromyces trifolii, in several varieties. 0, I, II, III on clovers. Pale brown pustules surrounded by torn epidermis, appear on underside of leaves and on petioles and stems.

Uromyces sp. **Rust** on birdsfoot trefoil.

Uropyxis

Pucciniaceae. Autoecious. Teliospores two-celled, on pedicels; uredia with paraphyses.

Uropyxis daleae var. **eysenhardtiae** (formerly *Uropyxis eysenhardtiae*). On *Dalea and Eysenhardtia* in Arizona.

Uropyxis eysenhardtiae (see *Uropyxis daleae* var. *eysenhardtiae*). On *Dalea* and *Eysenhardtia* in Arizona.

SCAB

Diseases characterized by an overgrowth of tissue in a limited area are commonly called scab. The hyperplastic scablike lesions correspond to the necrotic or dead areas of leaf spots and cankers. Diseases called scab caused by *Elsinoë* or its anamorph, *Sphaceloma*, are treated under Spot Anthracnose.

Cladosporium

► Blotch Diseases.

Cladosporium bruneo-atrum. Possible cause of russeting of citrus fruit hitherto attributed solely to citrus mite.

Cladosporium carpophilum (Syn. *Fusicladium carpophilum*), apparently a different strain from peach scab fungus. **Almond Scab**. Water-soaked symptoms on young shoots turn brown; leaves turn black, drop prematurely; circular, olivaceous spots coalesce on fruit.

Cladosporium carpophilum. **Peach Scab**, general on peach, widespread on apricot, nectarine, cherry, and plum. The form on cherry and European plum has been attributed to *Venturia cerasae* (*Cladosporium cerasi*). Small, round, olive black spots appear on infected fruits about 6 weeks after petals have fallen. These are usually on upperside of fruit, and cracking may follow. Twigs show nearly circular yellow-brown blotches with gray or bluish borders; cambium may be killed and twig die. Leaf spots are brown, scattered, with tissue drying and falling out, leaving circular holes.

Control. The brown-rot spray schedule should also control scab, a sulfur spray 4 to 6 weeks after petal fall being especially important. A fungicide can be combined with an insecticide spray for curculio.

Cladosporium caryigenum. **Pecan Scab**, **Leaf Spot**, general on pecan, and hickory. Scab is perhaps the most important limiting factor in pecan production in the Southeast. All varieties are somewhat susceptible, even those, like Stuart, that have been quite resistant in the past. Crop losses may reach 75 to 95%.

The fungus attacks rapidly growing tissue in leaves, shoots, and nuts; mature growth seems to be immune. On Schley and other highly susceptible varieties, primary infection shows in elongated olive brown lesions on veins and underside of leaves. With secondary infection leaves appear almost black, as a result of coalescing of spots; defoliation follows. On more resistant varieties, such as Moore and Stuart, infection is often delayed until the leaves are nearly mature, and so scab spots are confined to nuts. Nut lesions are small, black, circular, slightly raised at first, then sunken. Spots may be so close together that the entire surface turns black; the nuts drop prematurely or remain attached to shoots indefinitely. Infection is correlated with spring and early summer rainfall, continuous moisture for 6 to 8 hours being required for the spores to germinate and enter the host. First lesions appear in 1 or 2 weeks.

Control. Knock off old shucks and leaf stems before trees leaf out in spring. When they are wet after a rain, a slight jarring of branches will make such diseased material drop. Prune off low limbs for better air circulation. Four protectant sprays are required in Georgia, five in Florida.

Cladosporium cladosporioides f. sp. **pisicola** (formerly *Cladosporium pisicola*). **Pea Scab**, **Black Spot** of pea. Dark spots covered with velvety mold are formed in moist weather on leaves, stems, where black streaks may develop into cankers and pods may be distorted. The fungus is seed-borne, and lives in soil in plant refuse.

Cladosporium coreopsidis. Reported on coreopsis in Wisconsin, causing stunting and suppression of flowering.

Cladosporium cucumerinum. **Cucumber Scab**, general on cucumber in greenhouses, an important transit and storage decay of muskmelon, sometimes serious on late-planted squash. The disease was first noted in New York in 1887. Leaves with water-soaked spots may wilt, stems have slight cankers, but most injury is to the fruit. First symptoms, while cucumbers are still small, are gray, slightly sunken spots, sometimes exuding a gummy substance. They darken with age, and the collapsed tissue forms a pronounced cavity, lined with a dark green velvety layer of greenish mycelium, short conidophores, and dark, one- to two-celled spores. On leaves, these fruiting fascicles are extruded through stomata. The disease becomes epidemic after mid-summer, when night temperatures are cold or with heavy dews and fog.

Control. Resistant cucumber varieties include Maine No. 2, Wisconsin SR 10, SR 6, and Highmoor. A long rotation is advised.
Cladosporium pisicola (see *Cladosporium cladosporioides* f. sp. *pisicola*). **Pea Scab**, **Black Spot** of pea.

Fusarium

► Rots.

Fusarium heterosporum. **Head Scab** of tall fescue.

Spilocaea (Fusicladium)

► Leaf Spots.

Fusicladium dendriticum (see *Spilocaea pomi*). Conidial stage of the apple-scab fungus. ► *Venturia inaequalis*.
Fusicladium eriobotryae (see *Spilocaea pyracanthae*). **Loquat Scab**, widespread on leaves, stems, fruit of loquat.
Fusicladium photinicola (see *Spilocaea photinicola*). **Christmasberry Scab** on *Photinia arbutifolia*.
Fusicladium pyracanthae (see *Spilocaea pyracanthae*). **Pyracantha Scab**, widespread on leaves and fruit.
Fusicladium saliciperdum (Syn. **Venturia chlorospora**) (see *Pollaccia saliciperda*). **Willow Scab**, **Blight**, first noticed on willow in Connecticut in 1927, apparently introduced from Europe.
Pollaccia saliciperda (formerly *Fusicladium saliciperdum* (Syn. *Venturia chlorospora*). **Willow Scab**, **Blight**, first noticed on willow in Connecticut in 1927, apparently introduced from Europe. Repeated defoliation has killed thousands of trees in the Northeast. Young leaves are attacked and often killed in spring, almost within a few hours, and from the leaf blades the fungus enters twigs, kills back young shoots, and causes cankers. Olive green felty spore masses are formed on the long veins on underside of leaves. Overwintering is as dormant mycelium in twigs infected the previous spring. Another fungus, *Physalospora miyabeana*, is found with the scab fungus, and the two together form the disease complex known as willow blight. *Physalospora* usually attacks later in the season than *Fusicladium* and causes cankers on larger stems.

Control. Prune heavily to remove diseased parts. Spray with bordeaux with excess lime.

Spilocaea photinicola (formerly *Fusicladium photinicola*). **Christmasberry Scab** on *Photinia arbutifolia*. Brown velvety spots appear on leaves, flower stalks, and green berries; the berries being disfigured when mature. Prune in winter to remove dead wood and foliage. Spray before blossoming with bordeaux mixture.

Spilocaea pomi (formerly *Fusicladium dendriticum*). Conidial stage of the apple-scab fungus. ► *Venturia inaequalis*.

Spilocaea pyracanthae (formerly *Fusicladium eriobotryae*). **Loquat Scab**, widespread on leaves, stems, fruit of loquat. This is similar to pear and apple scab. Dark velvety spots cause more or less deformation of fruit, but the disease is seldom important.

Spilocaea pyracanthae (formerly *Fusicladium pyracantha*). **Pyracantha Scab**, widespread on leaves and fruit. The unsightly black scabs spoil the appearance of bright berries. The fungus winters in the mycelial state in attached leaves. Frequent spraying with bordeaux mixture controls scab but causes some defoliation.

Spongospora

Plasmodiophoromycetes, Plasmodiophorales

Spores in a hollow sphere with several openings; zoosporangia formed; zoospores anteriorly bi-flagellate; sexual fusion of myxamoebae.

Spongospora subterranea. **Powdery Scab** of potatoes, **Canker**, **Spongy Scab**. Indigenous to South America and introduced into Europe more than a century ago, potato scab was not noticed in North America before 1913, in Maine. Ordinarily not important, it causes economic loss in some seasons.

Slightly raised pimples appear on tubers when they are less than an inch in diameter; they are varying shades of brown on the surface, faintly purple underneath. The epidermis, not growing as fast as the pimple, breaks and curls back over the pustule, which, by this time, is a brown powdery mass of spore balls and decomposed plant tissue. The lesions are often “corked off,” but under favorable conditions large, depressed cankers may form. The fungus winters on stored tubers or in soil, remaining viable for many years. In the presence of a potato tuber and enough moisture, each spore in the ball germinates by swarmspores, which stay grouped together in a plasmodium, dissolving cuticle and killing cells. When the food supply diminishes, the plasmodium again breaks up into spore balls.

Control. Avoid low soggy ground; if such soil must be used, acidify it with sulfur as for common scab.

Streptomyces

► Rots.

Streptomyces acidiscabies. **Acid Scab** on beet, carrot, radish, parsley and turnip.

Streptomyces scabies (Syn. *Actinomyces scabies*). **Common Scab** of potatoes, **Beet Scab**, **Corky Scab**, **Actinomycosis**, general on potatoes, widespread on beets, also reported on carrot, parsnip, radish, rutabaga, and turnip. This disease may have been in America as long as potatoes have been grown, but the causal organism was not described until 1890. Scabby potatoes, by lowering the market grade, mean an annual loss of several million dollars. Chief symptoms are the tuber lesions, starting as minute brown specks and progressing to scabs that are warty or with corky ridges, or are pitted and depressed with the skin cracking open. Such potatoes can be eaten, but have poor customer appeal and are wasteful because of the deep peeling required. On beets, the scabs are similar but more bulging.

The pathogen can be found even in virgin soil. It invades young tubers and may sometimes be seen as a grayish coating on freshly dug potatoes. It is most destructive in soils with pH 5.7 and over, with its activity sharply limited in soils slightly more acid. Although its optimum temperature is 72° to 86°F, the fungus can withstand great extremes of temperature and moisture and can pass through the digestive tract of animals, returning to the field in manure.

Control. Seed tubers have been treated with formalin, but the organism is so prevalent in potato soils that such treatment may have little result. Soils already slightly acid may be further acidified with sulfur. Enough sulfur to acidify highly alkaline soil would be too expensive and too injurious to potatoes. Alkaline materials – time, wood ashes, and manure – should not be applied to potato soil. Somewhat resistant varieties include Menonimee, Ontario, Cayuga, and Seneca.

Venturia

Ascomycetes, Pleosporales, Venturiaceae

Perithecia setose, often only near apex, papillate; paraphyses absent; spores unequally two-celled, olive.

Venturia cerasi. On cherry and European plum, perhaps a strain of the peach scab fungus but not infecting peach.

Venturia inaequalis (Anamorph, *Spilocaea pomi*). **Apple Scab**, **Scurf**, **Black Spot**, general on apple except in far South, widespread on crabapple; reported also on mountain-ash and hawthorn, but probably other species of *Fusicladium* infect these hosts. Scab is the world's top-ranking apple disease and is probably coextensive with the host. In this country it takes a fourth or more of the crop in a favorable scab year, the average national loss running around 8%, or over 10 million bushels. Scab is somewhat less important in the South and in irrigated sections of Washington, but it is important in the humid coastal areas (Fig. 3.58). The pathogen was first described and named by Fries in Sweden in 1819 and was recognized in New York and New Jersey in 1834, apparently having come here with some European imports.

Symptoms. The first symptom of scab on leaves is a dull smoky area that changes to an olive-drab moldy spot, 1/4 inch or more in diameter, without a sharp outline. Sometimes the leaf is raised or domed in the vicinity of the

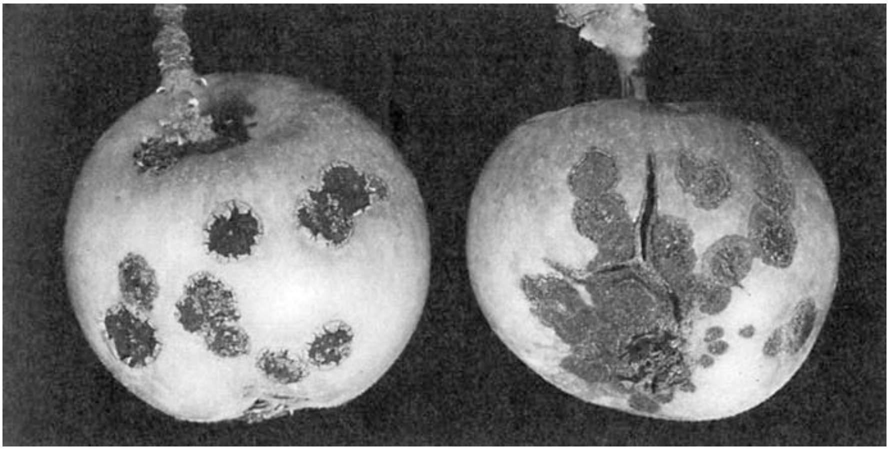


Figure 3.58 Apple Scab on Leaf and Fruit

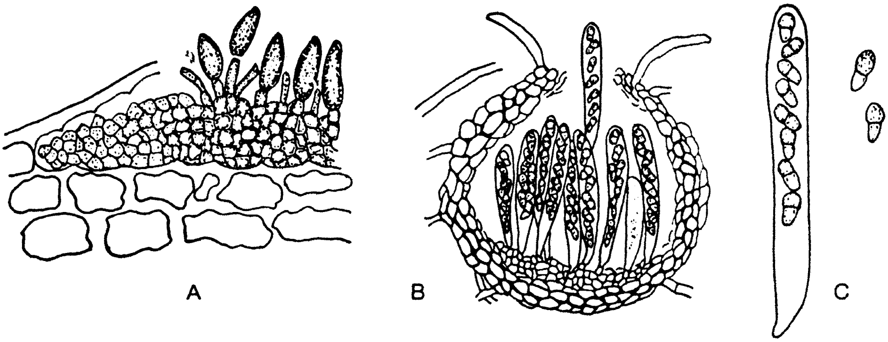


Figure 3.59 *Venturia inaequalis*, the apple-scab fungus. **A** one-celled dark conidia of *Fusicladium* stage; **B** perithecium with two-celled ascospores

spot; sometimes it turns brown and drops prematurely. Similar spots may be formed on blossom pedicel, calyx, and petals, followed by dropping of young fruit. Scabby lesions sometimes appear on twigs, but are less common.

On fruits, spots are small, more or less raised, rounded, dark olive areas (see Fig. 3.58). As they increase in size, the cuticle ruptures to form a white rim around a dark, velvety center, and still later the center may be raised, corky, and tan in color, after dark mycelium and spores have disappeared. Lesions are usually most abundant near calyx end of fruit; if they are too numerous, the fruit splits.

Life History. The fungus winters in dead fallen leaves, producing small, dark, flask-shaped perithecia and, toward spring, asci with eight brown ascospores, unequally two- celled, with the upper cell wider than the lower (Fig. 3.59). The ascospores mature about the time blossoms show pink, and are forcibly expelled during warm spring rains. Each ascus elongates, protrudes its tip through the mouth of the perithecium, and explodes its spore content. When a spore, carried by wind, arrives on a young leaf or bud, it penetrates the cuticle with a germ tube and develops a layer of branching mycelium just under it. The scab spot is evident in about 10 days, when brown conidiopores bearing olive brown, one-celled, somewhat pointed spores appear on the surface. Secondary infection occurs when these conidia are carried to new infection courts.

The expulsion of ascospores proceeds in a series of discharges over a rather long period, up to 3 months, starting in February, on the West Coast, but a shorter period, beginning in April, in New York. Germination and infection take place from 41° to 79°F. Length of wetting period necessary for primary infection decreases as the temperature rises – 13 to 18 hours of continuous wetting at 43°F and only 4 to 6 at 70°F. Secondary infection from conidia continues all season in rainy periods and even in storage scab may show up on apples infected just before picking.

Control. No varieties are immune to scab. Resistance varies with the season and the part of the country. McIntosh apples are very susceptible; Baldwins are fairly resistant but may scab badly some years. There is more than one strain of the fungus. Nitrogenous fertilizers increase yield of the fruit but also susceptibility to scab.

Protective spraying, having a chemical film on blossom, fruit, or foliage at all times when weather makes infection probable, is the only real answer to scab. This may mean more than a dozen applications in a wet year and a minimum of five any season, a program more suited to the commercial grower than to the amateur. Timing is all-important, and most states have a spray warning service that tells of imminent discharge of ascospores. Any spray schedule must be tailored for the locality, the season, and apple varieties grown. The apple grower gets this specific help from his county agents.

Venturia pyrina (Anamorph, *Fusicladium pyrorum*). **Pear Scab**, general on pear, also on quince, similar to apple scab. The pear species of *Venturia* overwinters in fallen leaves and also in affected twigs; the perithecia mature somewhat later than those of apple scab. Conidia are formed on pear twigs and washed to leaves and fruit.

Pear scab is not serious except on such varieties as Flemish Beauty, Winter Nelis, Seckel, Anjou, Bosc, and Duchess. Bartlett pears are rather resistant.

SCURF

Two diseases, one of sweetpotatoes and one of potatoes, are commonly called scurf.

Monilochaetes

Deuteromycetes, Hyphomycetes

Hyphae and conidiophores dark, spores hyaline, one-celled, oblong-cylindric, in chains.

Monilochaetes infuscans. **Sweetpotato Scurf**. Small, circular, brown or black spots are formed on all underground parts, often forming a uniform patch over the whole potato or a black patch on red-skinned varieties. The skin cracks, and potatoes shrink in storage. The black conidiophores stick up from the surface of the lesions like bristles. The fungus winters on the roots and on decaying vines.

Control. Scurf, formerly present in 50% of New Jersey sweetpotatoes, is now rare because of proper care. Set only healthy sprouts, grown from potatoes bedded in sand that has not grown sweetpotatoes before.

Helminthosporium (Spondylocladium)

Deuteromycetes, Hyphomycetes

Conidiophores dark, straight, septate, the upper cells bearing whorls of conidia; conidia dark with three or more cells.

Helminthosporium solani (formerly *Spondylocladium atrovirens*). **Silver Scurf** of potatoes. **Scab**, **Dry Rot**, present in almost all potato districts but not too important. Light brown lesions become somewhat blistered, giving the skin a marked silvery appearance. The disease is only skin deep, and control measures are seldom used.

Spondylocladium atrovirens (see *Helminthosporium solani*). **Silver Scurf** of potatoes. **Scab**, **Dry Rot**, present in almost all potato districts but not too important.

SLIME MOLDS

Slime molds belong to the Myxomycetes, a group intermediate between bacteria and fungi. Their assimilative phase is a plasmodium, which is transformed into distinct fructifications on a substratum. They are not parasitic and are often found in rotting logs. Sometimes they are a nuisance in lawns, for the plasmodium after ingesting decayed organic matter or microorganisms for food moves up a grass blade for fruiting. Their spores are produced on or in aerial sporangia and are spread by wind. On absorbing water the spore cracks open and the contents escape as a swarmspore, sometimes two, with two flagella. The swarmspore ingests food like an amoeba, divides by fission into a myxamoeba, unites with another to form a zygote, which enlarges, with mitotic division, into a multinucleate plasmodium. There are many species. Two only are listed here, as being common on turf.

Fuligo septica (formerly *Mucilago spongiosa*). Cream to yellow plasmodium forms large grayish white structures, 2 to 6 cm long by 1 to 6 cm wide, that are lobed and branched sporangia filled with a dark mass of purple, spiny spores.

Mucilago spongiosa (see *Fuligo septica*).

Physarum polycephalum. Plasmodium colorless, watery-white or yellow. Fruiting bodies small, gray, sessile, crowded on grass blades, and scattered in groups or rings over an area of several feet. Spores are purple brown in mass. The sporangia develop during humid weather in summer and autumn. Use a stream of water to wash the spore masses off the grass.

SMUTS

Smuts, of the fungus order Ustilaginales, are named for their sooty black spore masses. Like the rusts, they belong to the Basidiomycetes and are all plant parasites, of most economic importance on cereals and grasses, but they differ from rusts in having a less complicated life history and in being able to live part of their lives saprophytically in rich organic matter or in culture media. There are two spore forms. The teliospore, usually called a chlamydospore, is formed by the rounding up of a hyphal cell. In addition to a thin inner endospore wall, it has a thick outer exospore wall, usually dark, smooth or ornamental. Teliospores are formed singly or united into balls. They can be distributed long distances by wind, and spores of some species remain viable for years. Some have to ripen several months before they can germinate.

Occasionally the teliospore puts out a germ tube that penetrates host tissue directly. More often it produces a promycelium that gives rise to sporidia, which can bud to more sporidia. Classically true smuts have been divided into two families on the type of sporidial formation: Ustilaginaceae, with sporidia produced on the sides of a four-celled promycelium, and Tilletiaceae, with sporidia produced at the end of a one- or two-celled promycelium. Fischer, however, points out that there are so many variations that it is preferable to include all species in a single family, Ustilaginaceae, and to differentiate the species on the basis of morphological characters and the host family. This is logical, but we include here the families as they are given in most textbooks and also the false smuts, Graphiolaceae (Ustilaginales), which have an uncertain taxonomic position.

There are three types of infection with smuts, with control measures modified according to type. The mycelium always penetrates the young host tissue directly; it does not enter through stomata.

1. Infection of seedlings as the seed germinates, from spores adhering to the outside of the seed or present in soil; controlled by dusting seed and planting in noninfested soil.

2. Seedling infection by mycelium within the seed as a result of ovary infection from spores germinating on the stigma; controlled by treating seed with hot water.
3. Infection of any actively growing meristematic tissue (roots, shoot, tassels, or young ears) by spores transported by wind from decaying plant material; controlled, partially, by spraying or dusting susceptible plants.

Burrillia

Tilletiaceae. Sori in various host parts, often in leaves, rather permanently embedded. Spore balls with a central sterile mass surrounded by fertile teliospores but no sterile cortex (surface layer). Teliospore hyaline to yellowish, rather firmly united. On water plants.

Burrillia decipiens. **Leaf Smut** of floating heart (*Nymphoides*).

Cintractia

Ustilaginaceae. Sori usually in ovaries, black, more or less agglutinated spore masses with a peridium. Teliospores single, olive to reddish brown, formed from a fertile stroma surrounding a central columella of host tissues. On Cyperaceae and Juncaceae.

Doassansia

Tilletiaceae. Sori usually in leaves; spore balls large and conspicuous, with a sterile layer around fertile cells. Teliospores pale yellowish brown to hyaline, thin walled. Germination often *in situ*. On water plants.

Doassansia epilobii. **Leaf Smut** on epilobium.

Entyloma

Tilletiaceae. Sori generally in leaves forming light spots, giving the name white smut, or slightly raised darker blisters. Teliospores produced singly but often adhering in irregular groups – hyaline to pale green, yellow, or brown. Sporidia formed on the surface give the white powdery appearance.

Entyloma calendulae. **Calendula White Smut**. Spots are pale yellow, turning brown to black, 1/4 inch in diameter. The smut is common but not very serious in commercial calendula plantings around San Francisco. Plant debris should be cleaned up, perhaps the location changed.

Entyloma compositarum, **White Smut** of composites, boltonia, calendula, erigeron, eupatorium, gnaphalium, golden-glow, helenium, and prairie coneflower.

Entyloma dactylidis (*E. crastophilum* and *E. irregulare*). **Bluegrass Blister Smut**, on *Poa* spp., Oregon, Washington, Minnesota, North Dakota. Gray-black, blister areas in leaves from subepidermal masses of chlamydospores. A series of fine dotlike masses of sporidia (conidia), appear scattered in rows along surface of the blisters.

Entyloma dahliae. **Dahlia Leaf Smut**, a European disease occasionally reported here. It showed up in one location in California where overhead watering was used, but disappeared when the practice was discontinued. Leaves are marked by more or less circular spots, first yellow-green, then brownish and dry. Primary spores germinate in leaves and send projections to the outside, where secondary spores are formed to spread the disease. Late planting seems to increase disease incidence.

Entyloma ellisii. **Spinach Smut**. An occasional disease with infected leaves pale and worthless. Spores are produced in irregular, marginal necrotic lesions.

Entyloma lineatum. **Smut** of wild rice.

Entyloma polysporum. **Leaf Smut** of gaillardia, golden-glow, senecio, sylphium, andsunflower.

Graphiola

Ustilaginales. This family and genus are sometimes included in the smuts, sometimes not. The sori are erumpent, enclosed in a compact black peridium on leaves of palms. The spores are formed in parallel chains, and bud laterally to form two or more sporidia, which become somewhat colored with thickened walls.

Graphiola phoenicis. **False Smut** of palms, **Leaf Spot** on queen, canary date, royal and Washington palms and on palmetto. Leaves are yellow-spotted with small black scabs or warts having a dark, horny outer surface and long, flexuous sterile hyphae protruding from an inner membrane containing powdery yellow or light brown spore masses. Seriously infected

leaves may die. The disease occurs on date palm where humidity is continuously high, but is checked in desert areas best suited to date culture. Kustawy variety is less susceptible than some others.
The disease also appears on small ornamental palms in greenhouses and conservatories. Cut out and burn infected leaves or parts.

Mycosyrinx

Ustilaginaceae. Spores united in pairs; sori with a double peridium in swollen pedicels and peduncles. Mostly tropical.

Mycosyrinx osmundae. **Inflorescence Smut** on osmunda fern.

Neovossia

Tilletiaceae. Sori in ovaries, semi-agglutinated to powdery. Teliospores borne singly, each with a long pedicel appendage, and producing many sporidia.

Neovossia iowensis. On grains, affecting kernels in the dough stage.

Schizonella

Ustilaginaceae. Sori in leaves; short to long striae; black, agglulinated teliospores in pairs, germinating with three- to four-celled promycellium with lateral sporidia. Two species on Cyperaceae.

Sorosporium

Ustilaginaceae. Spores loosely united into balls, readily separable by pressure, in various hosts, more often in reproductive parts. Germination by promycelium and sporidia or germ tube. Mostly on grains.

Sorosporium saponariae. **Flower Smut** of silene.

Sporisorium

Ustilaginaceae. Sori in various host parts but mostly in inflorescence; granular to powdery, covered at first by a peridium. Teliospores single, formed around a central columella. Germination usually with sporidia. Most species on grains and grasses, sometimes causing severe stunting.

Sphacelotheca cruenta (see *Sporisorium cruentum*). **Loose Kernel Smut** on sorghum, causing smutting and excessive branching.

Sphacelotheca reiliana (see *Sporisorium holci-sorghi*). **Head Smut** of corn, in Pacific states and scattered locations in South.

Sphacelotheca sorghi (see *Sporisorium sorghi*). **Covered Kernel Smut**. Kernels replaced by smut galls

Sporisorium cruentum (formerly *Sphacelotheca cruenta*). **Loose Kernel Smut** on sorghum, causing smutting and excessive branching. Controlled by seed treatment and resistant varieties.

Sporisorium holci-sorghi (formerly *Sphacelotheca reiliana*). **Head Smut** of corn, in Pacific states and scattered locations in South. Galls on tassels and ears breaking into loose dark brown spore masses. Do not plant in a smutted field for 2 years; use certified seed, resistant hybrids.

Sporisorium sorghi (formerly *Sphacelotheca sorghi*). **Covered Kernel Smut**. Kernels replaced by smut galls.

Thecaphora

Ustilaginaceae. Sori in various host parts, mostly inflorescence; powdery or granular. Spores firmly united into balls, with no sterile cells. Chiefly on Leguminosae and Convolvulaceae.

Tilletia

Tilletiaceae. Sori mostly in ovaries, occasionally in vegetative parts of host forming a powdery or semi-agglutinated spore mass, often foetid. On grains and grasses, called bunt; interior of seed a solid mass of spore balls (see Fig. 3.60).

Tilletia buchloëana. **Bunt** of buffalograss.

Tilletia caries. **Dwarf Bunt** of wheat. Plants a fourth or half size of healthy plants.

Tilletia foetida. **Stinking Smut**, **Common Bunt** of Wheat, on wheat and wheat grasses wherever grown, occasionally on rye. A major agricultural disease, especially in Pacific Northwest, this is of historical importance as the first disease controlled by seed disinfection. In 1670 a ship was wrecked

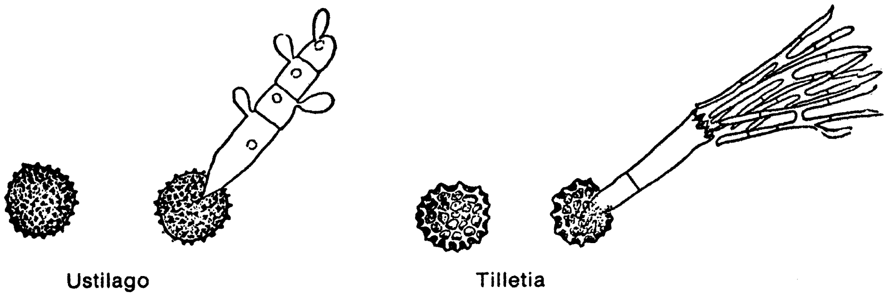


Figure 3.60 Smut Spores. *Ustilago* (left), spiny chlamydospore germinating with promycelium and sporidia formed at sides; *Tilletia* (right), reticulate chlamydospore with long H-shaped sporidia formed at end of promycelium and sometimes forming small secondary sporidia

off the Coast of England, but the cargo of wheat was salvaged, free from bunt because of its salt-water bath. Dark smut balls replace kernels, and there is a fishy odor. Plants are stunted, but not as much as with dwarf bunt. Spore balls are broken in threshing and seed contaminated. Many materials are offered for seed treatment. Seed dealers treat seed for farmers in special machinery at low cost.

Tilletia pallida. **Bunt** on velvet and creeping bent grass, Oregon, Rhode Island. Seeds are filled with black spores, plants stunted. The disease is serious where grass is grown for seed, with up to 80% nonviable seed.

Urocystis

Tilletiaceae. Sori mostly in leaves and stems, blackish; embedded in host tissues. Spore balls permanent, without sterile cortex but sometimes with a layer of hyaline, hyphal fragments. On Liliaceae, Primulaceae.

Tuburcinia trienthalus (see *Urocystis trientalus*). **Leaf and Stem Smut** of starflower.

Urocystis trientalus (formerly *Tuburcinia trientalus*). **Leaf and Stem Smut** of starflower.

Urocystis

Tilletiaceae. Sori usually in leaves, stem sheaths, occasionally in flowers; dark brown to black, powdery to granular. Spore balls with distinct sterile spores on the surface, only a few fertile spores. Sori without peridium.

Urocystis agropyri. **Flag Smut** of wheat, also on wheat grass, red top, and bluegrasses. Symptoms are similar to those of stripe smut.

Urocystis anemones (including *U. hepaticae-trilobae*). **Leaf and Stem Smut** of anemone, hepatica, and trautveteria.

Urocystis carcinodes. **Smut** of aconite, baneberry, clematis, and cimicifuga.

Urocystis colchici (Fischer includes *U. cepulae* in this species). **Leaf Smut** of autumn crocus, camassia, Solomons-seal and false Solomons-seal.

Urocystis gladiolicola. **Gladiolus Smut**. This disease had been intercepted several times at quarantine and appeared once in California fields, in 1950, but apparently is eradicated there. Growers should be on the lookout for corms with low blister swellings, with ridges paralleling veins, bluish black, breaking open to expose dense black spore balls. Seedlings exhibit blistering, shredding, and necrosis of stem and leaf tissues; they die if the disease is severe.

Urocystis kmetiana. **Floral Smut** of field pansy (*Viola bicoler*).

Urocystis magica (*U. colchici*). **Onion Smut**, general on onion, also on leek, shallot, garlic, and chives. This is the most destructive onion disease, found in the Connecticut Valley as early as 1861 and thence spread to all northern onion-growing sections, but more important where onions are grown from seed rather than sets as in most home gardens.

Black elongated blisters or pustules of spores break out on scales or leaves of young plants. Many plants die; others survive and have black or brown smut pustules on the cured bulbs. Plants are stunted but not rotten, although smut may be followed by secondary rot organisms.

The spores can live in soil for years, but infection is possible only in young plants from the second day after seed germination until the seedling is in first leaf, a period of 10 to 15 days. The spore is able to penetrate the onion through root and cotyledon but cannot enter a true leaf. After entrance it spreads through the seedling until it reaches the leaves to form fruiting pustules just below the epidermis. When this ruptures, spores are dropped, to be disseminated by running water and tools, on feet of persons and animals, and on roots of transplanted vegetables. Onion smut is confined to states with cool summers, optimum soil temperature for infection being 72°F.

Urocystis tritici. **Flag Smut** of wheat. Plants are dwarfed with twisted leaf blades; sheaths are marked with grayish-black stripes; diseased tissues dry up and are shredded. Infected plants rarely produce heads.

Ustilago

Ustilaginaceae. Sori in various host parts; spore masses powdery to agglutinated; usually dark brown to black, in some species yellow to purple without a peridium. Spores single, not united in balls (see Fig. 3.60).

Ustilago avenae. **Nigra Loose Smut**, general on barley.
Ustilago avenae (including *U. perennans*). **Black Loose Smut** on oats and some grasses. Individual flowers in panicle are largely replaced by a spore mass. The young seedling is diseased from the seed, and the fungus grows systemically in the plant.
Ustilago buchloes. **Stripe Smut** on grass.
Ustilago bullata. **Head Smut** on many grasses.
Ustilago esculenta. **Smut** on wild rice.
Ustilago heufleri. **Erythronium Smut**. Large dusty pustules lead to cracking and dying of leaves of dogtooth violet.
Ustilago hordei. **Covered Smut** of barley. Heads are converted into hard, black, smutted masses, enclosed within thin membranes.
Ustilago kolleri. **Covered Smut** of oats. Spore balls remain intact within glumes until threshing, when spores are distributed over surface of seed, ready to infect young seedlings.
Ustilago maydis (*U. segetum*). **Corn Smut**, **Boil Smut**, general on corn but most destructive to sweet corn. The average annual loss is 3 to 5% but it can be 100% in any one field. The fungus was described in Europe in 1754 and not reported here before 1822, but it may be native along with its host. There are many physiological races, and smut resistance is likely to be correlated with lack of vigor, so that it has been hard to breed desirable resistant varieties.
Any plant parts aboveground may be attacked – stalks, prop roots, leaves, tassels, husks, and ears (see Fig. 3.61). Large boils are formed, at first covered with a greenish white membrane, said to be good eating when boiled or fried. Later the membrane breaks and releases myriads of dark chlamydospores. The plant is often distorted. Infections are local; each boil is formed where a spore lands, and there is no systemic growth through the plant. The fungus is not seed-borne, and germinating seedlings are not affected. Chlamydospores winter in soil, corn debris, and manure. They produce sporidia, which may bud to form secondary sporidia, and these are carried by wind and other agencies to corn plants, which are 1 to 3 feet high. Mycelium from

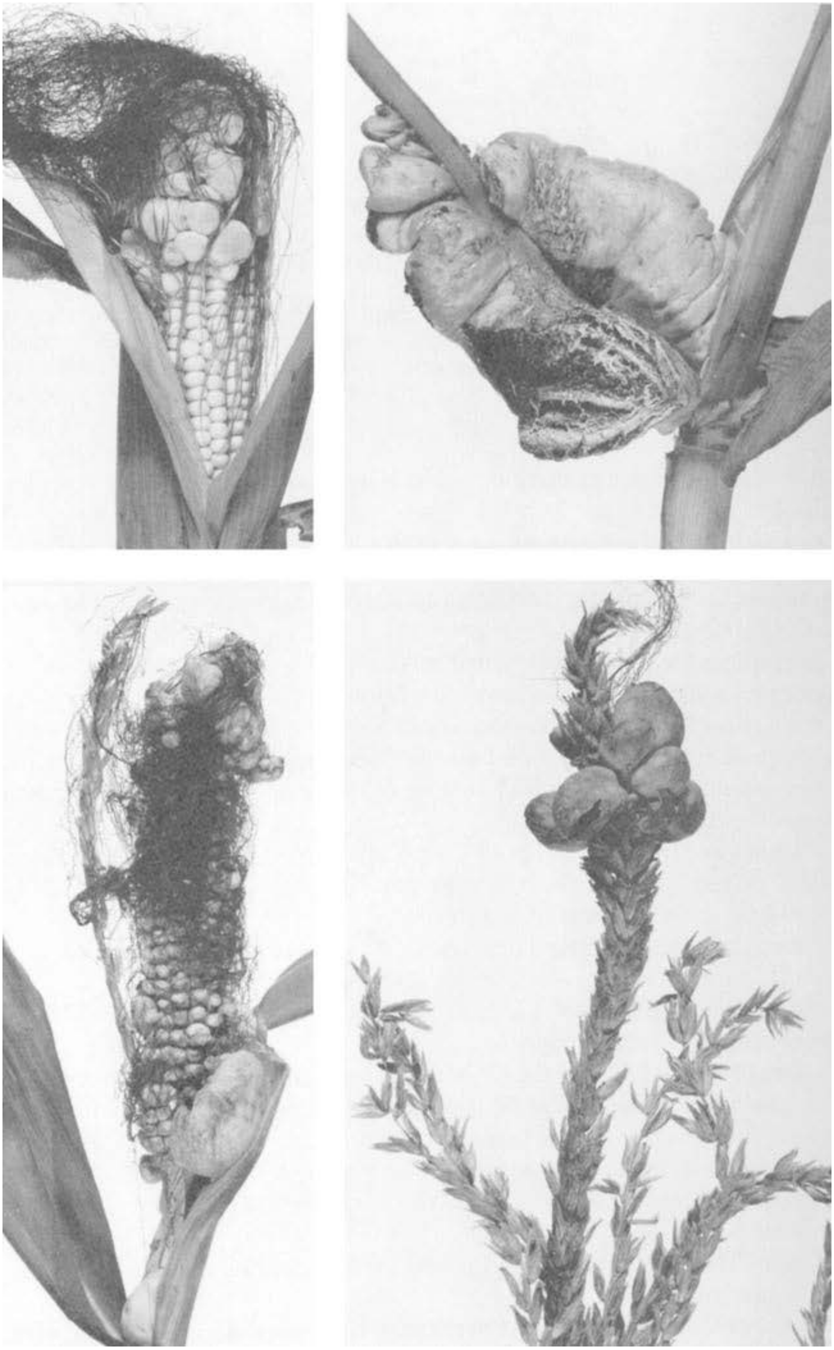


Figure 3.61 Corn Smut

spores of two sexes is needed for active development. Spores formed in the first boils provide inoculum for secondary infection of ears.

Corn smut thrives in warm weather, optimum temperature for spore germination being 80° to 92°F. Heaviest infection occurs when scant rainfall in early stages of growth is followed by moderate rainfall as corn approaches maturity. Vigorous plants are most susceptible, but may escape the most serious effects because of their rapid growth. Spores retain viability 5 to 7 years. They remain viable in passage through an animal into manure, but are killed by the acids in silage.

Control. Seed treatment is not effective. Some hybrid varieties are rather resistant. Most reliance in home gardens should be placed on cleanliness, cutting off and burning all smutted parts before the boils break open to release spores.

Ustilago mulfordiana. **Fescue Smut** on fescue grasses.

Ustilago tritici. **Nuda Loose Smut**. Normal heads replaced by black powdery masses.

Ustilago striiformis. **Stripe Smut**, general on grasses – wheatgrasses, redtop, bentgrasses, fescues, ryegrass, and bluegrass; does not occur on cereals. Long dark narrow striations develop in leaves; as the sori mature, spores are freed, and the blade splits into ribbons. Plants are systemically infected, make poor growth, and inflorescences are stunted or absent. Perennial mycelium may overwinter in the plant.

Ustilago violacea. **Anther Smut** of carnation, dianthus, lychnis, and silene. Infected plants grow slowly, produce many weak axillary shoots; stem internodes are shortened; flower buds are short and squatty; calyxes tend to split; flowers are sprinkled with black sooty dust from the anthers, whose pollen grains are replaced by smut spores. The fungus enters through flowers or injured surfaces and grows systemically. Spores are spread on cuttings. Control by roguing diseased plants before flowering. Do not take cuttings from plants with grassy or bushy habit.

SNOWMOLD

Northern lawns and turf of golf greens often show round light patches as the snow melts in early spring. Such a disease is called snow mold and may be due to one of several fungi, sometimes to two appearing together.

Microdochium (Fusarium)

► Rots.

Fusarium nivale, Teleomorph, **Monographella nivales**). (see *Microdochium nivale*). **Pink Snowmold**, **Fusarium Patch**, most important on bentgrass on golf courses but infecting other turf grasses and winter wheat and winter rye.

Microdochium nivale (formerly *Fusarium nivale*, Teleomorph, *Monographella nivales*). **Pink Snowmold**, **Fusarium Patch**, most important on bentgrass on golf courses but infecting other turf grasses and winter wheat and winter rye. Irregularly circular patches, from 1 to 2 inches to a foot or more, appear as snow is melting. They are whitish gray, often with a pinkish tinge, and several patches may run together to cover large areas. Individual plants have a bleached appearance, feel slimy when wet. Spores are formed in salmon-pink sporodochia over stomata in leaves. They are sickle-shaped, one- to three-septate. Perithecia are produced on the luxuriant white mycelial mat.

Abundant moisture in the fall, snow falling on unfrozen ground, deep snow, and a prolonged, cold wet spring are predisposing factors, but the presence of snow is not a requisite for the disease. Severity is increased by applying fertilizer in late autumn and an excess of organic matter in the soil. Reports differ as to susceptibility, but Colonial, Washington and Metropolitan bentgrasses appear to be more resistant then Seaside bent.

Sclerotium

► Blights.

Sclerotium rhizodes. **Frost Scorch**, **String of Pearls**, in northern states. Not exactly a snowmold but appearing in early spring with bleached, withered leaves covered with rows of tiny sclerotia. Collect clippings when mowing diseased areas to remove sclerotia on leaf tips.

Typhula

Basidiomycetes, Aphyllophorales

Fruit body erect, simple, like a little club, on a long stipe from a sclerotium; basidia with four sterigmata and simple, hyaline spores.

Typhula incarnata. **Snowmold** of turf and lawn grasses, **Typhula Blight**, common in eastern United States. As the snow disappears in spring, a felty white mycelial mat is seen over grass and adjacent soil. Plants wither and turn light brown or tan in roughly circular patches, very conspicuous against the green of the rest of the lawn. The chief diagnostic character is the presence of very small, tawny to hazel brown spherical sclerotia in large numbers over affected parts. These can be made to fruit in the laboratory into rose-colored sporophores up to 1 inch tall.

Control. The disease gradually disappears as moisture decreases and temperature and sunlight increase; so control seldom seems necessary. Six weeks after striking cases of snowmold, lawns are often uniformly green and show little sign of having been affected. Phosphate fertilizers are said to decrease injury from *Typhula*.

Typhula idahoensis. **Snowmold** on wheat and grasses in Idaho and Montana. Sclerotia are chestnut brown, sporophores fawn to wood brown, less than 1/2 inch high.

SOOTY MOLD

Sooty mold is a black coating on surface of leaves or fruit composed of a weft of dark mycelial threads. As here used, the term applies to saprophytic fungi that live on insect honeydew and harm plants only indirectly. See ►Black Mildew for the true parasites with dark mycelium and spores giving a sooty appearance to foliage.

Capnodium

Ascomycetes, Capnodiales

Mycelium superficial, dark; spores muriform, in perithecium-like conceptacles at tips of branches of a carbonaceous stroma; associated with insect secretion on living plants.

Capnodium citri. **Sooty Mold** on citrus, on honeydew secreted by scale insects, aphids, whiteflies, especially abundant following whiteflies in Florida, black scale in California. A black velvety membranous coating is formed over leaves, twigs, and fruit. If honeydew is slight, the coating appears in spots; but if the insect secretion is abundant, the entire surface may be covered by a dense continuous membrane resembling black tissue paper. With age, under dry conditions it may be blown off in fragments. The black membrane is made up of hyphae that are individually olive green to deep brown, with wide short cells. Branches may crisscross or be cemented together. There are several spore forms: simple conidia that are cut off from upright hyphae, others formed in small, black pycnidia, stylospores in very long flask-shaped conceptacles, and muriform brown ascospores in perithecia.
Although sooty molds do not obtain food from the plant, the black membrane interferes greatly with photosynthesis and food manufacture. Affected fruit is smaller, with coloring retarded; it is more likely to decay than normal fruit.
Control is directed against the insects, either by spraying with insecticides or by using entomogenous fungi and insect parasites. Oil sprays kill the insects and help to clean the trees of the sooty covering.

Capnodium elongatum. **Sooty Mold** of tulip-tree, oleander, holly-osmanthus, and others. Foliage of tulip-trees very frequently has a black coating, often on honeydew secreted by the tulip-tree aphid, sometimes following attacks of tulip-tree scale. A dormant oil spray controls the latter.

Capnodium spp. **Sooty Mold** on gardenia, fig, crape-myrtle, azaleas, and many other plants. Gardenias are especially subject to sooty mold following whiteflies, crape-myrtle after aphids, azaleas after mealybugs and magnolias after scales. A summer oil spray helps to control the insects and loosens the black coating so that it is more readily washed off.

Very often rhododendrons and other broad-leaved evergreens growing inside the branch spread of tulip and other trees afflicted with aphids and scales are covered with sooty mold growing in the honeydew dropped down on foliage from the tree overhead.

Fumago

Deuteromycetes, Hyphomycetes

Mycelium dark, creeping over surface of leaves; conidiophores dark, variable, bearing conidia terminally or laterally; conidia variable, dark, muriform, frequently in chains; saprophytic on honeydew; probably conidial stage of *Capnodium*.

Fumago vagans. A heavy black moldlike growth on leaves of linden and many other ornamental trees and shrubs, also on house plants in honeydew from aphids, mealybugs and scale insects.

Scorias

Ascomycetes, Capnodiales

Mycelium with parallel walls, forming a thick spongy mass; perithecium long-stalked, round; spores four-celled.

Scorias spongiosa. **Sooty Mold**. Often on trees – alder, beech, pine, etc.

SPOT ANTHRACNOSE

Diseases caused by species of *Elsinoë* anamorph state *Sphaceloma*, are characterized by some overgrowth of tissue. When this hyperplasia is pronounced, the disease is usually called scab; when the overgrowth is scarcely noticeable (merely a slightly raised border around a necrotic center), the disease has been commonly known as anthracnose. Recently, the term spot anthracnose was introduced to differentiate a *Sphaceloma* malady from anthracnoses caused by fungi with slime spores (*Colletotrichum, Glomerella*) and from the *Venturia* type of scab diseases. Consequently, all spot anthracnose diseases are included in this section, but with the common designation, scab or anthracnose, also listed.

Elsinoë

Ascomycetes, Myriangiales, Elsinoaceae

Asci are borne singly, at different levels, in an effused stroma, having a gelatinous interior and crustose rind, under or within the epidermis, which ruptures to expose the asci. The anamorph state is a *Sphaceloma*.

Elsinoë ampelina. **Grape Anthracnose**, **Bird's Eye Rot**, widespread on grape. Small sunken spots with dark margins and light centers occur on fruit, young shoots, tendrils, petioles, and leaf veins. Leaves may be distorted and ragged from diseased portions dropping out. Outbreaks are sporadic in eastern states. Varieties Catawba, Campbell Early, Diamond, Norton, and Salem are quite susceptible; Concord, Delaware Moore Early, and Niagara are resistant. The fungus winters on canes.

Control. Apply a dormant lime-sulfur spray and four or five sprays of bordeaux mixture: when new shoots are 7 to 8 inches long; just after bloom; 7 to 10 days later; and when berries are half grown.

Elsinoë cinnamomi. **Camphor-Tree Scab**. Inconspicuous brown leaf spots, sometimes dropping out; elongated raised lesions on veins, petioles, and stems. Reported from South Carolina.

Elsinoë corni. **Dogwood Spot Anthracnose**, a serious threat to flowering dogwood from Delaware to Florida, also reported from Louisiana. Infected buds do not open, or they produce stunted, malformed "flowers," marked with numerous small, circular to elongated spots with light tan centers, purple to brown borders, up to 50 on a bract. Leaf spots are 1 to 2 mm, slightly raised at the margin, purple paling to yellow-gray at centers, which may be broken in a shot-hole effect. There may be 100 spots on a leaf, scattered or concentrated at tip, margin, or midrib. Spots on petioles, fruit clusters, and stems are similar to leaf spots.

Elsinoë diospyri. **Spot Anthracnose** on leaves of native persimmon, reported from Florida, 1955.

Elsinoë euonymi-japonici. **Spot Anthracnose** on evergreen euonymus, Florida. Small, roundish spots, mostly on upper surface of leaves, brown with raised, orange-cinnamon margin; stem cankers circular to elliptical, wrinkled or fissured, grayish white with raised orange margins.

Elsinoë fawcettii. **Sour Orange Scab**, **Citrus Scab**, **Verrucosis** on citrus fruits, except rare on sweet orange. Lemons, sour orange, King orange, bitter orange, and calamondin are very susceptible; Mandarin and Satsuma oranges, tangerines, and all grapefruit except Royal and Triumph are moderately susceptible. Climatic conditions play a part. Grapefruit and lemons in the Rio Grande Valley are less susceptible than in Florida, but Satsumas in Alabama are more susceptible than those in Florida. Known in the Orient since ancient times, scab is believed to have come to Florida on Satsumas from Japan. It was first recorded there in 1885; the fungus was identified as a *Sphaceloma* in 1925.

Tender growth is most readily infected, and the disease is most important on young trees. On leaves, minute, semitranslucent spots change to raised excrescences with corky crests, pale yellow to pinkish, then dull olive drab with a conical depression opposite the crust. Foliage may be wrinkled or stunted. Fruits have slightly raised scabs or are warty with corky crests, which may grow together into large irregular patches. Scabs on grapefruit may flake off as the fruit matures, with the area remaining green.

Spores are spread by wind, rain, dew-drip, possibly by insects. The young fruit of grapefruit is very susceptible right after petal fall, but becomes progressively resistant and is practically immune when it reaches 3/4 inch in diameter. Temperature range for severe infection is from 59° to 73°F. Excessive nitrogen increases scab. The pathogen winters on infected leaves, sometimes fruits.

Control. Apply a neutral copper spray or bordeaux mixture just before growth starts in spring. A second copper spray, just after flowers shed, controls melanose as well as scab.

Elsinoë ilicis. **Chinese Holly Spot Anthracnose**. Numerous black spots, 1 to 2 mm, coalesce to large black patches on upperside of leaf mostly the apical half, with distortion. Shoots and berries have brown to gray lesions with slightly raised margins.

Elsinoë jasminae. **Jasmine Scab**. Reported from Florida. Spots numerous, round or irregular, up to 2 mm.

Elsinoë ledi. **Ledum Spot Anthracnose**, widespread on ledum, Labrador tea, and salal in Northwest, leucothoë in Florida. Leaf spots are grayish white with red-brown borders and purple margins. The disease is not serious.

Elsinoë lepagei. **Scab** on sapodilla and canistel in Florida (found on young nursery stock in cans). Small, raised spots, gray at center.

Elsinoë leucospila. **Camellia Scab**, also recorded on ternstroemia in Florida. Some corky excrescences on camellia foliage are due to this pathogen, others to moisture relations.

Elsinoë magnoliae. **Magnolia Scab** on *Magnolia grandiflora* from Georgia to Louisiana. Spots are circular to angular, with black papillae in centers, on upper leaf surface along midrib, margin, or tip. Infected leaves may drop.

Elsinoë mangiferae. **Mango Scab**. Spots usually originate on underside of young mango leaves but become visible above. They are circular to angular, dark brown to black with olive buff centers. Spots on mature leaves are larger, slightly raised with narrow brown margins and dirty white centers. Stems have irregular grayish blotches; fruit, gray to brown spots with dark margins.

Elsinoë mattirolianum. **Spot Anthracnose** on madrona and strawberry tree (*Arbutus* spp.) in California.

Elsinoë parthenocissi. **Virginia Creeper Soft Anthracnose**. Leaf spots are few to numerous, circular, scattered or along midribs and veins; they have buff centers with narrow brown margins; fruit spots are grayish white; lesions on petioles are somewhat raised. Also reported from pepper-vine.

Elsinoë phaseoli. **Lima Bean Scab**. First United States report from North Carolina probably from imported seed. Lesions on pods, stems, and leaves.

Elsinoë piri. **Pome Fruit Spot Anthracnose** on pear, apple, and quince in moist sections of western Washington and Oregon, more prevalent in home gardens than commercial orchards. Fruit spots are small, up to 2 mm, red or reddish purple with pale centers, upwards of 100 on an apple.

Elsinoë quercicola. **Spot Anthracnose** on water oak, Florida.

Elsinoë quercus-falcatae. **Spot Anthracnose** on southern red oak, Georgia, South Carolina. Blackish brown leaf spots are few to abundant, scattered over upper surface.

Elsinoë randii. **Pecan Anthracnose**, **Nursery Blight** on pecans in the Southeast, an important nursery disease, limiting factor in production of budded pecans in wet seasons. Small reddish lesions develop on both leaf surfaces, those on the upper surface later turning ash gray. Diseased tissues become brittle and fall out, leaving ragged margins and perforations. Spray trees with bordeaux mixture when first leaves are half grown; follow with three sprays of bordeaux at 3- to 4-week intervals.

Elsinoë rosarum. **Rose Anthracnose**, widespread on rose, collected on wild roses as early as 1898, in most areas more important on climbing roses than on hybrid teas. Leaf spots are scattered or grouped, sometimes running together, usually circular, up to 1/4 inch. Young spots are red, varying brown or dark purple on upper leaf surface, showing up to 2 to 6 days after inoculation but not visible on under surface for 2 to 4 weeks, then dull reddish brown to pale purple. On aging, the center of the spot turns ashen white, with a dark red margin. Leaves may turn yellow or reddish in area of spots, may have slits or perforations as the centers fall out.

Cane spots are circular to elongated, raised, brown or purple, with depressed light centers and acervuli in barely visible dark masses. The fungus winters in cane spots; spores are produced and spread only in rainy periods. A single leaf lesion may produce 10,000 spores within an hour after wetting and will continue production as long as the rain lasts.

Control. Where possible, prune out infected canes in spring. Keep foliage protected as for blackspot. Sulfur and copper compounds are effective.

Elsinoë solidaginis. **Goldenrod Scab** in Florida, South Carolina, and Georgia. New growth is affected as it develops. Lesions formed on midrib, veins, petioles, and leaf blades are raised on one surface, sunken on the other, with white to gray centers and brown borders.

Elsinoë tiliae. **Linden Spot Anthracnose** reported from Nova Scotia and Virginia. Gray spots with black margins are numerous on leave blades and petioles.

Elsinoë veneta. **Bramble Anthracnose**, general on blackberry, dewberry, raspberry, being most common on black raspberry. Circular, reddish brown sunken spots with purple margins and light gray centers, up to 3/8 inch in diameter, appear on young shoots. On older canes these grow together into large cankers. Similar spots, not always with purple margins, are formed on fruit, leaf, and flower stalks. Leaf spots are first yellowish, then with a red margin around a light center, which may drop out. Leaves may drop prematurely; fruit may dry up as a result of loss of water from infected canes. Primary spring infection comes from ascospores produced in old lesions on canes; secondary spread is by conidia.

Control. Cut old canes or "handles" from black raspberries after setting; remove and burn old fruiting canes after harvest. In some cases the single late dormant spray has controlled anthracnose without later sprays; in others three foliage sprays have been effective without a dormant spray. Black raspberry Quillen is quite resistant.

Sphaceloma

Deuteromycetes, Coelomycetes

Acervuli disc- or cushion-shaped, waxy; conidiophores simple, closely grouped or compacted, arising from a stromalike base; spores one-celled, hyaline, ovoid or oblong. Teleomorph state where known is *Elsinoë*.

Sphaceloma araliae. **Aralia Scab** on Hercules club (*Aralia spinosa*), Maryland and Missouri.

Sphaceloma cercocarpi. **Spot Anthracnose** of birch-leaf mahogany, in California. Leaf spots are nearly circular, up to 3 mm across, with pale centers and slightly elevated purple margins.

Sphaceloma hederae. **English Ivy Scab**. Leaf spots are raised with red-brown margins, pale depressed centers, often numerous.

Sphaceloma lippiae. **Lippia Spot Anthracnose** on fog-fruit. Closely resembling mint anthracnose and found in same fields in Indiana, also reported from Florida. Numerous spots on leaves and stems are scattered or grouped and nearly confluent; centers are depressed, buff-colored, with purple margins.

Sphaceloma menthae. **Mint Anthracnose**, **Leopard Spot Disease**. Circular, oval or irregular spots on leaves, stems, and rootstocks are black with white centers, up to 5 mm. Formerly serious, this disease is now controlled in commercial mint fields by fall plowing, covering plants deeply.

Sphaceloma morindae. **Morinda Scab**. Buff-colored spots on leaves, stems, and petioles, Florida.

Sphaceloma murrayi. **Gray Scab** of willow. Leaf spots are round, irregular, somewhat raised, grayish white with narrow, dark brown margins, often confluent, sometimes fragmenting; long narrow patches along veins.

Sphaceloma oleandri. **Oleander Scab**. Leaf spots spherical to irregular, densely grouped over entire surface, whitish with brownish black margin, slightly elevated, 1 to 4 mm.

Sphaceloma perseae. **Avocado Scab**, one of the most important avocado diseases in Florida, some years with nearly 100% infection; also occurring in Texas. Leaf lesions are mostly on upper surface, very small red spots with a dark olive conidial growth. Fruit lesions are corky, raised, brownish, oval, but often coalescing giving a russeted appearance; sometimes cracking to allow entrance of fruit-rotting fungi. Avoid highly susceptible varieties like Lulu. Spray with bordeaux mixture as for blotch.

Sphaceloma poinsettiae. **Poinsettia Scab**. Light raised lesions on stems, veins, and midribs, pale buff at center with purple to nearly black margins.

Sphaceloma psidii. **Guava Scab**, reported in feijoa in Florida.

Sphaceloma punicae. **Pomegranate Spot Anthracnose**. Very small purple spots with paler centers on both leaf surfaces.

Sphaceloma ribis. **Gooseberry Scab**, Washington. Leaf spots numerous, very small, raised, and grayish.

Sphaceloma spondiadis. **Mombin Scab**. On purple mombin (*Spondias*) Florida.

Sphaceloma symphoricarpi. **Snowberry Anthracnose**, widespread on snowberry, impairing beauty of ornamental plants, first described from New York in 1910; also on coralberry. Leaf spots appear in early spring, minute, dark purple to black, aging with dirty gray centers, coalescing into large areas subject to cracking. Leaves may be misshapen from early marginal infections. Spotting is inconspicuous in flowers but pronounced on berries, with purple areas becoming sunken and pinkish. Secondary infection by an *Alternaria* shrivels fruit into brown mummies. A dormant lime-sulfur spray followed by foliage sprays may help.

Sphaceloma viburni. **Snowball Spot Anthracnose**.

Sphaceloma violae. **Violet Scab**, **Pansy Scab**, widespread on violet and pansy from Connecticut to Louisiana and Texas, a limiting factor in maintaining violet collections. Reddish spots with white centers change to irregular to elongated raised scabs on leaves and stems, often with much distortion. Remove and burn old leaves.

Sphaceloma spp. Undetermined species have been reported on *Bignonia*, catalpa, camellia, and sambucus, in Louisiana, on buttonwood in Florida, rhododendron in Washington.

VIRUS, VIROID, PHYTOPLASMA – PATHOGENS AND DISEASES

For many years the classification of plant viruses was in a state of chaos. Fortunately recent biochemical and molecular investigations on organization and structure of genome as well as on structural and nonstructural viral proteins provided enough data to create a definition of species. A virus species is a polythetical class of viruses consisting of replicating lineage and occupying a particular ecological niche. This indicated that viruses and biological entities that possess genes, replicate, interact with hosts and are exposed to selection pressure, thus specialize and evolve. Guidelines provided in the Sixth and Seventh Reports of the International Committee or the Taxonomy of Viruses are partly followed, especially by use of a virus species name or vernacular name for the not fully described viruses. Following are virus species (including viroids and phytoplasmas) and virus diseases in alphabetical order by common names.

Abelia Latent Tymovirus

Symptomless on Abelia; occurs in Eastern USA.

Abutilon Infectious Variegation; Abutilon Mosaic Bigeminivirus

A single variegated seedling found among green plants imported into England from the West Indies in 1868 was propagated vegetatively as an ornamental variety. The bright yellow mottling on green leaves tends to disappear in subdued light. Transmission is by grafting, occasionally by seed, and, in native Brazil, by whitefly *Bemisia tabaci*. Plants may recover if variegated leaves are persistently removed but may be reinfected.

Albutilon Yellows Closterovirus

Transmitted by Triaulerodes abutilonea. Infected plants are chlorotic.

Alligatorweed Stunting Closterovirus

Occurs in North America region and Florida.

Alfalfa Mosaic Alfamovirus

Potato, Celery Calico; Bean Yellow Dot. Various strains of the alfalfa virus are transmitted by cotton, pea, and other aphids to bean, clovers, pea, cucumber, potato, tomato, zinnia, tumbleweed, poison hemlock, wild carrot, Japanese pachysandra, and other hosts. Calico is a minor potato disease in California and Idaho. Leaf spots are irregular, brilliant yellow to gray; yield may be reduced. Celery has a conspicuous yellow-green mosaic; bean has small, necrotic lesions.

Almond Bud Failure

Virus on Drake almond, in California, is transmissible by grafting. Limbs have many branches, some dead at the end; leaves are darker green, more upright, retained longer than normal; fruits few, often misshapen.

Almond Calico

On almonds in California, graft transmissible. Chlorotic blotches in leaves.

Alstroemeria Mosaic Potyvirus and Alstromeria Streak Potyvirus

Both viruses are transmitted by aphids in a non-persistent manner.

Alternanthera Mosaic Potexvirus

Found in Florida, Maryland, and Pennsylvania on skullcap, firecracker plant and moss rose.

Apple Chlorotic Leaf Spot Trichovirus

Originally considered as a closterovirus but now is the type species of Trichovirus genus.

Apple Green Mottle

On Duchess variety in New York. Fruit with discolored rings, of little value.

Apple Mosaic Ilarvirus

Occurring naturally only on apples; no insect vector known; transmitted by budding. Small irregular cream to yellow leaf spots coalesce to large chlorotic areas, with or without vein-banding. Three strains cause severe mosaic, veinbanding mosaic and mild mosaic. There is no marked reduction in yield. Hosts other than members of Rosaceae family include filbert, hop, birch, and horse chestnut.

Apple Stem Grooving Capillovirus

First reported in Viriginia Crab. The main symptoms are stem grooves and abnormal graft union.

Tulare Apple Mosaic Ilarvirus

Reported from California; has a wider host range than apple mosaic.

Apple, Dapple

Fruit with circular islands or patches remaining green; on trees with Virginia crab or Robusta V bodystock; first noted in New Hampshire.

Apple Stem-Pitting

Wood-pitting in Virginia Crab bodystock, sometimes followed by bark cracks, dwarfing, early fruit production.

Apricot Gummosis

First noted in Washington in 1947; transmitted by budding. Profuse gumming on branches and trunks, necrosis and dieback of new shoots; dead, punky areas in fruit.

Apricot Ring Pox

In California and Colorado. Irregular ring spots with marked vein clearing in some varieties, chlorotic mottling in others; dead tissue may fall out leaving shot holes. Fruit bumpy or with reddish brown necrotic spots extending into flesh.

Arabis Mosaic Nepovirus

It is one of the viruses that causes lilac yellow ring symptoms. Occurred on many genera of ornamental, vegetable and orchard plants. Transmitted by nematodes. This virus causes foliar blanching on hosta.

Artichoke (Globe) Curly Dwarf Potexvirus

In California on artichoke, cardoon, and zinnia, milk thistle. Leaves curled, plants dwarfed, killed.

Artichoke Latent Potyvirus

Symptoms on *Cynara* spp. are none or stunting and yellow flecking of plants.

Ash Ring Spot = Arabis Mosaic Nepovirus

On white ash, New York. Chlorotic green and reddish spots, rings, line patterns; stunting; dieback.

Ash Witches' Broom

Reported from Louisiana on Arizona ash. Yellowish leaves, a fourth to a third normal size; multiple, spindly shoots.

Asparagus 1 Potyvirus

Symptomless on *Asparagus officinalis*.

Asparagus 2 Ilarvirus

Caused stunting and decline on *Asparagus officinalis* plants. Virus is transmitted by pollen to the seed and to the pollinated plant.

Aster Chlorotic Stunt Carlavirus

Reported in Aster novae-angliae in Ontario, Canada.

Aster Ring Spot

In Florida on China aster, pepper, pansy, and other plants. Yellow ring, line, and oakleaf patterns. A strain of Tobacco Rattle Tobravirus.

Avocado Sun Blotch Viroid

There are long, narrow, shallow, longitudinal grooves, buff-colored on stems, whitish on green fruit, reddish purple on purple fruit. Shoots may be twisted and abnormal. Transmitted through seeds.

Avocado 3 Alphacryptovirus

Transmitted only by seeds.

Barley Yellow Dwarf Luteovirus

Occurs on tall fescue, and various *Poa* and *Festuca* spp. Occurs on cereal crops in Alaska.

Barley Yellow Streak Mosaic

Occurs on barley in Alaska.

Bayberry Yellows

Wavy margins and tips on young apical leaves, distorted margins on older leaves, which are pale, yellow, small. Plant is stunted, with shortened internodes, few or no fruits.

Bean Common Mosaic Potyvirus

Distributed worldwide in common beans wherever they are grown. Many strains of the virus were distinguished. They are transmitted by vectors, sap, pollen and seed. Virus is serologically related to 17 other Potyviruses.

Bean Mosaic = Bean Common Mosaic Potyvirus

Found wherever beans are grown, transmitted by many species of aphids – pean, cotton, cowpea, cabbage, peach, spirea, turnip – and in seed. First leaves are crinkled, stiff, chlorotic; older leaves have chlorotic mottling, often with leaf margins rolled down. Mosaic-resistant varieties include Robust, Great Northern, U.S. No. 5 Refugee, Idaho Refugee, and Wisconsin Refugee.

A strain known as bean greasy pod virus causes a greasy appearance of the pods in some western states. The asparagus-bean mosaic is a light and dark green mosaic with leaf rolling transmitted by seed and by the pea aphid. The virus may be a strain of bean mosaic virus or a different virus.

Bean Leaf Roll Luteovirus

Legume virus transmitted by aphids.

Bean Pod Mottle Comovirus

Systemic mottling in some varieties; circular, light brown local lesions on pods of other varieties. May also be seed transmitted in soybean.

Bean Southern Mosaic Sobemovirus

Chlorotic mottling or localized necrosis of foliage; pods with dark green blotches or shiny areas, slightly malformed, short, curled at end. Virus present in new seed but not in that stored 7 months.

Bean Yellow Mosaic Potyvirus

Mild Mosaic of Gladiolus. On beans, peas, sweet peas, clover, Tahitian bridal veil, gladiolus, false lupine, and freesia. In beans there is a coarse yellow mottling and distortion of leaves, which are pointed downward; proliferation of stems; shortening of nodes and general stunting; reduced pod production; delayed maturity. In pea and sweet pea there is veinal chlorosis, with slight ruffling. Gladiolus flowers are striped or flecked, young leaves have an angular green mottling, but symptoms are mild compared with the disease on beans and freesia, which should not be planted near gladiolus and clovers. The virus is transmitted by bean and pea aphids but not through seed. Rogue infected plants as soon as noticed.

Bean Yellow Stipple = Cowpea Chlorotic Mottle Bromovirus

Mild mottle and chlorotic spots on bean leaves, sometimes coalescing.

Beet 2 Alphacryptovirus

Transmitted only by pollen and seeds.

Beet Black Scorch

Necrovirus, Tombusriridae. Reported in Colorado.

Beet Curly Top Hybrigeminivirus

Confined to North America, curly top is especially important in the commercial sugar beet industry west of the Continental Divide, but it is common on many plants. Vegetables include bean, beet, carrot, celery, cabbage and other crucifers, cucumber, melon, squash, pumpkin, eggplant, spinach, chard, New Zealand spinach, horseradish, and tomato. Ornamentals include alyssum, blue flax, campanula, carnation, columbine, coreopsis, cosmos, delphinium, foxglove, geranium, larkspur, nasturtium, pansy, petunia, poppy, portulaca, pyrethrum, scabiosa, Shasta daisy, stock, strawflower, veronica, and zinnia.

In beets there are clearing of veins, leaf curling, with sharp protuberances from veins on underside of leaf, increase in number of rootlets. In tomato, where the disease is called western yellow blight or tomato yellow, seedlings turn yellow and die. Older plants show twisting and upward rolling of leaflets, stiff and leathery foliage, with leaf petioles curling downward; branches and stems are abnormally erect; the whole plant is dull yellow, often with purple veins; roots are killed, few fruits formed.

In cucurbits, tips of runners bend upward; old leaves are yellow, tip leaves and stems abnormally deep green. In beans, there is a thickening and downward curling of first true leaf, which becomes brittle. The plant stops growing and may die. Older plants survive until the end of the season, with puckering and downward curling at the top of the plant, reduction in size of new leaves, shortened internodes.

Ornamentals grown near diseased beets are usually infected. Zinnias have shortened internodes, chlorotic secondary shoots arising from leaf axils. Cosmos leaflets are twisted and curled, petioles bent down. Geranium leaves are chlorotic between veins with protuberances on lower surface.

The virus is confined to phloem in plants and is transmitted by the beet leafhopper (*Circulifer tenellus*). The insects winter on weed hosts, laying eggs and maturing the first generation there before migrating in swarms, often hundreds of miles, to sugar beet fields. When the beets are plowed out, the hoppers migrate to neighboring gardens.

Control. Destruction of weed hosts helps somewhat, as does early planting. There are resistant varieties of sugar beets, none of table beets. Tomatoes are sometimes protected with temporary muslin tents. Infected plants must be destroyed.

Beet Distortion Mosaic Virus

Transmitted probably by a fungus *Polymyxa betae*; spreads in California.

Beet Latent Virus

A symptomless virus in beets.

Beet Mosaic Potyvirus

On sugar and table beets, spinach. Discrete yellowish lesions, then chlorotic mottling, darkening of vascular tissue; leaves bend back near the tips, which sometimes die. Transmission is by pea, peach, bean, and other aphids.

Beet Ring Mottle

On sugar beet and spinach; stunting, distortion, mottling; transmission by aphids.

Beet Necrotic Yellow Vein Tobamovirus

On sugar beet and transmitted by soil-borne fungus *Polymyxa betae*.

Beet Pseudo-Yellows Closterovirus

Yellowing of sugar beet, carrot, spinach, cucumber, lettuce, and ornamentals; transmission by greenhouse whitefly.

Beet Savoy

Leaves are dwarfed, curled down, with small veins thickened; roots have phloem necrosis. A plant bug (*Piesma cinerea*) is the vector.

Beet Western Yellows Luteovirus

In Europe known as Beet Mild Yellowing Luteovirus. More than 150 species from 23 families are susceptible. Virus-transmitted by insects but principal natural vector is *Myzus persicae*.

Beet Yellow Net Luteovirus

On beets and chard. Leaves have a yellow network of veins against a green background. Transmission by the peach aphid.

Beet Yellows Closterovirus

On beets and spinach. Outer and middle leaves are yellowed, thickened, brittle, with chlorotic areas waxy. Vectors are peach and bean aphids.

Bidens Mottle

On *Rudbeckia, Zinnia*, and *Ageratum*.

Bidens Mottle Potyvirus

On *Rudbeckia, Zinnia*, and *Ageratum*.

Blackberry Dwarf

► Loganberry Dwarf.

Blackberry Dwarfing

On brambles in California.

Blackberry Mosaic

Mottling, crinkling, vein clearing and distortion.

Blackberry Variegation

On raspberry and blackberry. Infected leaves are nearly white at maturity.

Blackeye Cowpea Mosaic

On urd bean.

Blueberry Leaf Mottle Nepovirus

Reported on cultivars Rubel and Jersey in Michigan. Virus is transmitted by pollen and by honeybees which carry the pollen.

Blueberry Necrotic Ring Spot

A strain of tobacco ring spot virus, causing stunting and distortion; transmitted by dagger nematodes.

Blueberry Necrotic Shock Ilarvirus

Leaf and flower necrosis symptoms occurred for 1–4 years, then plants recover and remain symptomless.

Blueberry Red Ring Spot Caulimovirus

Red spots and rings, oak leaf patterns.

Blueberry Ring Spot

A minor disease chiefly on Cabot with red rings and dots in leaves.

Blueberry Scorch Carlavirus

Transmitted by grafting, it caused marginal chlorosis and necrosis of leaves but some cultivars remain symptomless.

Blueberry Shoestring Sobemovirus

Symptoms of “shoestring disease” included reddish streak on stem, narrow strap-like leaves and flower breaking.

Blueberry Shoestring Sobemovirus

On highbush bluberry.

Blueberry Stunt Phytoplasma

Bushes are dwarfed with small leaves, yellowing in summer, brilliant red in fall; berries are small, poor. Transmission by a leafhopper (*Scaphytopius magdalensis*). Variety Rancocas is quite resistant; Harding is tolerant. Eliminate wild blueberries near cultivated.

Broad Bean Severe Chlorosis Closterovirus

Caused chlorosis, necrosis and leaf malformation on broad beans.

Broad Bean Wilt Fabavirus

Virus is the type species of genus. It is known also as a catalpa chlorotic leaf spot, tropaeolum, nasturtium and petunia ringspots, pea streak virus and parsley virus 3.

Broad Bean Wilt Fabavirus

Causes leaf mottle, ring spots, and poor growth of fibrous-rooted begonia; also found on clockvine, bean, lettuce, spinach, lambsquarter, ajuga, and dogwood.

Brome Grass Mosaic

Recently reported on Kentucky bluegrass, in Kansas.

Brome Mosaic Bromovirus

On cowpea.

Cabbage Black Ring Spot

► Turnip Mosaic Potyvirus.

Cabbage Ring Necrosis = Turnip Mosaic Potyvirus

On cabbage and other crucifers, also infecting petunia, zinnia, calendula, cucumber, beet, chard, and spinach. Concentric necrotic rings on leaves and irregular dark, slightly sunken lesions on stems.

Cactus X. Potexvirus

On night-blooming cactus (*Hylocereus*).

Calibrachoa Mottle Carmovirus

Chlorotic blotch, leaf mottling and interveinal yellowing on *Calibrachoa* species.

Camellia Yellow Mottle Varicosavirus

Infectious Variegation; Color-Breaking. A graft-transmissible disease with at least four strains; CV1 – large white spots on petals; CV2 – small white flecks on petals, leaf variegation; CV3 – feathery mottling of flowers; CV4 – slower variegation and leaf mottle.

Canna Mosaic

Leaves with irregular pale yellow stripes from midrib to margin, parallel with veins, may be wrinkled and curled with chlorotic areas often dusty brown. Stems, sepals, and petals have yellow bands. Transmitted by peach and other aphids.

Canna Yellow Mottle Badnavirus

Bacilliform virions, not enveloped, 120–130 nm length and 28 nm wide. Virus caused systemic veinal yellowing, mottling and chlorosis of *Canna* spp.

Carnation Etched Ring Caulimovirus

Causes an etched-ring pattern on carnation leaves.

Carnation Italian Ringspot Tombusvirus

It is synonym for carnation strain of Tomato Bushy Stunt Tombusvirus.

Carnation Latent Carlavirus

This virus is serolocicaly related to potato viruses S and M, chrysanthemum virus B and other carlaviruses.

Carnation Mosaic

Widespread on carnation and sweet william. Light and dark green mottling in young leaves is followed by yellow or necrotic spots or streaks. Flowers may be spotted or striped. The vector is the peach, not the carnation, aphid. Greenhouse fumigation helps in control.

Carnation Mottle Carmovirus

Common in commercial carnations but producing only faint leaf mottling and flower streaks; transmitted by root contact or cutting knife.

Carnation Necrotic Fleck Closterovirus

Severe necrotic flecking and streaking to mild yellow flecks on carnation.

Carnation Ring Spot Dianthovirus

Concentric rings on sweet william with vein clearing, then general mosaic; necrotic rings on carnation, often combined with reddening and curling of older leaves. Sap-transmissible on cutting knife.

Carnation Streak

A strain of Carnation Necrotic Fleck Closterovirus. Yellow or reddish spots and streaks parallel to veins; lower leaves turn yellow and die. Graft-transmissible.

Carnation Vein Mottle Potyvirus

The best test for diagnosis of this virus is immunosorbent electron microscopy technique.

Carnation Yellows

Foliage mottling, flower streaking due to combination of streak and mosaic viruses.

Carrot Motley Dwarf = Carrot Mottle Umbrarvirus

An Australian disease now present in California. Leaflets are small, chlorotic, with twisted petioles; plants are stunted, roots unmarketable. Vectors are aphids.

Carrot Red Leaf Luteovirus

Transmitted by aphids in persistent manner, but does not multiply in the vector. No transmission by sap, seeds, or pollen.

Carrot Thin Leaf Potyvirus

Caused vein clearing and malformation of leaves (narrowing).

Cassava Common Mosaic Potexvirus

Reported from Florida, virus is transmitted by mechanical inoculation and by grafting.

Cauliflower Mosaic Caulimovirus

Widespread on crucifers, broccoli, brussels sprouts, cauliflower, chinese cabbage, collard, kale, annual stock, and honesty. Clearing of veins in cauliflower is followed by mild chlorotic mottling, with veins usually banded by dark green necrotic flecks. Midribs are curled, leaves distorted, plants stunted, terminal heads dwarfed. Stock is rosetted, with shortened internodes. Transmission is by cabbage, false cabbage, peach, and other aphids.

Celery Calico

On cucumber, crookneck squash, tomato, celery, and larkspur. In celery there are vein clearing, puckering, and downward cupping of younger leaves, green islands in yellows areas of outer leaves, yellow and green zigzag bands on leaflets. Basal and middle leaves of delphinium have orange-amber or lemon-yellow areas, chlorotic ring and line patterns; younger leaves are normal green. Transmission is by many species of aphids – celery, celery-leaf, rusty-banded, cotton, erigeron-root, foxglove, greenpeach, and honeysuckle.

Celery Mosaic Potyvirus

On celery, celeriac, and carrot in California. Young leaflets are mottled green and yellow, in advanced stages narrow, twisted, cupped; plants are stunted, with central leafstalks shortened, outer in a horizontal position with rusty necrotic spots. Transmission is by many species of aphids. A crinkle leaf strain of this virus causes a yellow mottle with raised blister areas and crinkling on celery leaves.

Celery Yellow Dwarf Poleroviridae

Occurs on cereal crops in Alaska.

Celery Yellow Spot Luteovirus

On celery and parsnip in California. Yellow spots and stripes, mostly along veins; circular white spots on petioles; transmission by honeysuckle aphid.

Cherry Albino

On sweet cherry in Oregon. Branches die back in spring; leaves golden brown with up-rolled margins; late summer, new growth small and rosetted; fruit small and white; trees soon killed. Transmission by tissue union.

Cherry Bark Splitting

On sour cherry and apricot.

Cherry Black Canker

On sweet cherry, Oregon. Black, rough cankers on twigs and branches.

Cherry Buckskin

► Peach Western X-Disease (under Bacterial Diseases, Phytoplasma).

Cherry Bud Abortion

On sweet and sour cherry.

Cherry Chlorosis

On Malaheb and chokecherry.

Cherry Freckle Fruit Disease

On sweet cherry.

Cherry Green Ring Mottle

On sour cherry.

Cherry Gummosis

On sour cherry. Dieback of terminal shoots, excessive gumming of branches.

Cherry Little Cherry

On sweet and sour cherry; fruits are half-size. Flowering cherry acts as a reservoir for the virus.

Cherry Midleaf Necrosis

Dark brown necrosis starting in midvein; heavy leaf fall; trees small and less vigorous but fruit normal. On sour cherry in Oregon.

Cherry Mora

Abnormal delay of a month or more in ripening fruit; leaves yellowish, small, rosetted, twisted on fruit spurs. On sweet cherry, Oregon.

Cherry Mottle Leaf Trichovirus

On sweet cherry in Northwest. Leaves show chlorotic mottling, are puckered, wrinkled, distorted but not perforated. Fruit is small, hard, insipid, uneven or delayed in ripening; crop is reduced. Branches are shortened, trees stunted. Transmission by grafting or budding with no insect vector known, but the disease spreads from wild bitter cherry to sweet cherry. Remove diseased trees. Propagate with scions from virus-free trees.

Cherry Necrotic Rusty Mottle

On sweet cherry. Foliage and blossoms delayed in spring; brown necrotic or rusty chlorotic spots, often with shot holes and defoliation.

Cherry (Sour) Pink Fruit

Fruit bitter, pink; tree stunted; foliage pale.

Cherry Pinto Leaf

On sweet cherry. Chlorotic patterns of varying size with disease tissue changing to bright yellow or white. Transmission by budding.

Cherry Rasp Leaf Nepovirus

Transmitted by nematode *Xiphinema amerciana*. Virus differs from other cherry diseases that cause leaf enations.

Cherry Rasp Leaf Nepovirus

On sweet cherry, in Northwest. Enations, elongated protuberances from underside of leaves with depressed lighter areas on upper surface.

Cherry Ring Spot = Prunus Necrotic Ringspot Ilarvirus

On sour cherry, sweet cherry (tatter leaf), peach, plum, prune, widespread in Northeast. Chlorotic or necrotic rings and spots on leaves, with lacerations to give the tatter-leaf effect. Transmission by grafting or budding, and, to a small extent, seed. Control by testing budwood sources on a differential host, such as Shirfugen variety of *Prunus serrulata*, sensitive to all strains.

Cherry (Flowering) Rough Bark

On Kwanzan flowering cherry. Internodes shortened; leaves in clusters and arched downward from necrosis and cracking of midribs; bark deep brown, rough with longitudinal splitting; trees dwarfed.

Cherry Rugose Mosaic = Strain of Prunus Necrotic Ringspot Ilarvirus

On sweet cherry. General chlorosis of leaf between midvein and margin, with distortion; fruit yield reduced; fruits flattened, angular. Transmission by grafting; incubation 9 months.

Cherry Rusty Mottle

On sweet cherry. Many leaves turn bright yellow to red with islands of green, and drop before harvest; remaining leaves have yellow-brown spots, rusty appearance; fruit is small, late, insipid. Remove diseased trees. Select grafting material from virus-free trees.

Cherry Twisted Leaf

On Bing cherry, severe stunting, leaves small, distorted, distal portion bent abruptly downward; sometimes defoliation.

Cherry Vein Clearing

Sweet Cherry Crinkle. A viruslike disease but not transmissible; probably genetic. Clearing of veins throughout leaves or in localized areas; margins irregular; some leaves with elongated, slotlike perforations; small blisters on lower side of veins, upper silvery. Leaves may fold along midrib, wilt and drop in midsummer. Rosetting of some branches. Blossoms abnormally abundant, but fruit reduced, pointed, flattened on one side with swollen ridge.

Cherry Yellows = Prune Dwarf Ilarvirus

Widespread on sour cherry. Yellow areas enlarge to cover whole leaves; defoliation. Diseased leaves and fruit larger than on healthy trees, but yield reduced by half. Transmission by budding and through seed.

Chickpea Filiform Potyvirus

On chickpea. Found in Washington State, but there is no evidence of spread.

Chrysanthemum Aspermy

► Tomato Aspermy Cucumovirus.

Chrysanthemum Chlorotic Mottle Viroid

Widespread in greenhouses and gardens. Bonnie Jean, Ridge, and Delaware varieties are used as indicators.

Chrysanthemum Flower Distortion

Apparently not widespread in United States. Virus is carried without symptoms in leaves of White Wonder, but if this is grafted to Friendly Rival, flowers are extremely dwarfed and distorted, with ray florets short, narrow, incurved, or irregularly curved.

Chrysanthemum Mosaic, Chrysanthemum B Carlavirus

Noordam's B, Keller's Q, and other virus strains are widespread in chrysanthemum with mild to severe leaf mottling and sometimes a brown streaking of flowers. Transmission is by grafting and by aphids. Control by indexing tips from heat-treated plants on reliable test varieties to make sure they are virus-free.

Chrysanthemum Ring Spot

Reported from Alabama in plants also afflicted with Stunt. Large yellowish chlorotic ring patterns, severe leaf dwarfing and distortion.

Chrysanthemum Rosette

A strain from symptomless Ivory Seagull produces veinbanding, crinkle, distortion, rosetting on Blazing Gold.

Chrysanthemum Stunt Viroid

Widespread in greenhouses and gardens. Symptoms vary with variety, but plants are dwarfed, with small flowers and leaves and bloom earlier than normal or later in some varieties. Blazing Gold, Blanche, Mistletoe, Dauntless, and Bonnie Jean often used as indicator varieties. Leaves of Blanche are crinkled, and Mistletoe has a "measles" pattern. Transmitted by dodder, sap-inoculation, grafting with incubation period 6 weeks or longer; no insect vector is known. Many plant species have been infected experimentally. Commercial growers go to great lengths to select and reselect a virus-free stock, and great care is taken to prevent recontamination. Garden varieties are now indexed and available.

Cineraria Mosaic

Mottling, dwarfing, and distortion of leaves, transmitted by seed, mechanically, and by *Aphis marutae*

Citrus Enation – Woody Gall Luteovirus

Found in different species of Citrus, Ulmus, Morus, Rosa, Prunus, Viburnum and Ecualyptus.

Citrus Exocortis Viroid

Probably same as Rangpur lime disease; in Florida and Texas on red grapefruit and sweet orange trees, on Rangpur lime and trifoliate orange rootstocks. Trees are stunted with bark shelling.

Citrus Leaf Rugose Ilarvirus and Citrus Variegation Ilarvirus

Disease known as citrus psorosis virus complex. Viruses spread in California and caused psorosis of young leaves and malformation of the old ones.

Citrus Leprosis Rhabdovirus

Transmitted by mite-vector *Brevipalpus phoenicis*.

Citrus Psorosis Complex: Citrus Leaf Rugose Ilarvirus, Citrus Ringspot Virus, Citrus Variegation Ilarvirus

Found wherever citrus is grown. Leaf symptoms are small elongated white or yellow areas near veins. Bark symptoms are scales or small pustules with irregular growth and gum deposits. With B strain of the virus, leaves have dots, rings, or large translucent areas and small corky pustules; fruit has surface rings. In the concave gum strain, cavities develop on trunks and larger limbs. The blind-pocket strain usually produces troughlike depressions in bark, sometimes bark scaling. The crinkly leaf strain, usually on lemon, causes warping and pocketing of mature leaves, and rough, bumpy fruit. Transmission is by budding or through natural root grafts.

Remove trees with advanced infection; use budwood from trees known to be free from psorosis. Sometimes bark can be scraped, going several inches beyond the margin of affected areas and painting the scraped areas with bordeaux paste.

Citrus Ringspot Virus

Caused epinasty, chlorotic flecks, leaf mottling Ringspot and large irregular chlorotic pattern on mature leaves of *Citrus* sp.

Citrus Stubborn Disease

Oranges have multiple buds, abnormal branching, acorn-shaped fruit, which is sour and bitter at the navel end.

Citrus Tatter Leaf Cappillovirus

Reported from California and Texas on Meyer lemon and lime. Blotchy spotting of younger leaves and ragged margins.

Citrus Tristeza Closterovirus

Quick Decline. In California, Florida, and Texas; usually in trees on sour orange rootstock. First symptoms are partial or complete suppression of new flushes of growth. Older leaves are dull or bronzed, later yellow. Defoliation continues progressively from base of twigs to tip. Rootlets and then roots die. Limbs die back, and weak shoots are produced from main limbs and trunk. Transmission is by melon and other aphids. Make new plantings with stock-scion combinations known to be resistant. Best rootstocks are sweet orange, rough lemon, Rangpur lime, and sweet lime.

Citrus Vein Enation

In California on sour orange, Mexican lime, and other citrus. Veins swell and enations develop on lower surface. Transmission by grafts and aphids.

Citrus Xyloporosis

Cachexia. In Florida, chiefly on sweet lime rootstock, but also on mandarins and some of the tangelo oranges. Symptoms include stunting of 2- or 3-year trees, small yellow leaves, partial leaf drop, early blooming and fruiting; horizontal growth of branches in middle section of trees; dieback, followed by decay of entire trunk and roots. Fruits are more rounded, with a thicker rind. Transmission is by budding, possibly through seed. Use resistant rootstocks, as sour oranges of Israel and Bagdad, Valencia orange.

Citrus Yellow Vein

In California on limequat. Petioles and veins are bright yellow.

Clerodendron Zonate Ring Spot

In Florida on "bleeding-heart" vine. Chief symptoms are cleared veins.

Clover Club Leaf

On crimson clover. Young leaves are light-colored, have club leaf appearance due to delayed opening. Yellow margins of leaves turn red or purple during summer. Transmission by a leafhopper.

Clover (Alsike) Mosaic = Clover Yellows Vein Potyvirus

On pea, causing chlorotic spotting and dark green banding of veins, leaves slightly cupped or distorted. Leaf puckering and plant stunting on bean. Pea aphid is vector.

Clover (Red) Vein Mosaic Carlavirus

On garden pea, causing pea stunt, broad bean, sweet pea, and red clover. Vein clearing and chlorosis are chief symptoms with, on peas, curling of leaves and rosetting of younger shoots, wilting, and collapse. Vein clearing is the only symptom on sweet pea. Broad beans may be stunted and killed. Transmission is by the pea aphid without incubation period or long retention. The Wisconsin pea stunt virus may be a strain of the red clover virus.

Clover Yellow Mosaic Potexvirus

Transmitted by mechanical inoculation; serologically related to White Clover Mosaic, Cactus X and Hydrangea Ringspot Potexviruses.

Clover Yellow Vein Mosaic

On winged bean, wild carrot, poison hemlock, and red bean.

Clover Wound Tumor Phytoreovirus

Big vein disease, causing enlargement of veins, sometimes with enations, woody tumors on roots, sometimes stems. The virus was discovered accidentally in leafhopper nymphs and has been transmitted experimentally to many plants besides clovers.

Cocksfoot Streak Potyvirus

Caused chlorotic streaks on leaves of *Dactylis glomerata*.

Coleus Mosaic = Cucumber Mosaic Cucumovirus

Reported from Illinois on coleus, symptoms varying with variety. Leaves may be puckered, crinkled, asymmetrical, with oak-leaf markings or ring spots or small necrotic spots.

Commelina Diffusa Potyvirus and Commelina Mosaic Potyvirus

Both viruses infected *Commelina diffusa* and *Rhoeo spatecea* on which mosaic or systemic mottling symptoms occurred. Both viruses induced pinwheel structures in the cytoplasm.

Coriander Feathery Red Vein Nucleorhabdovirus

Virus multiplies in vectors (*Myzus perscicae and Hydaphis foeniculi*) and is transmitted congenitally to the progeny of the vector.

Corn Leaf Fleck

On field and sweet corn in California. Small, circular pale spots on leaves with tip and marginal burning, leaves dying 7 to 10 days after initial symptoms. Transmission by corn, peach, and apple grain aphid, which retain the virus for their entire lives.

Corn (Sweet) Mosaic

Leaves have broken or continuous interveinal chlorosis.

Cotton Leaf Curl Bigeminivirus

Caused chlorosis, thickening and malformation of veins, petioles and leaves on *Gossypium barbadense* and *Hibiscus esculentus* plants.

Cowpea Chlorotic Mottle Bromovirus

Reported in peanut, common bean, cowpea and soybean plants.

Cowpea Mosaic Comovirus

Clearing of veins is followed by chlorotic mottling, slight convex cupping of leaflets, shortened internodes, abortion of flowers, twisting of petioles, and delayed maturity. Yield is reduced. Vectors are potato, pea, and cotton aphids. Another cowpea mosaic, known in Trinidad and probably the same as one in the United States, is transmitted by bean leaf beetles. May infect soybeans, hoary-tick clover (*Desmodium canescens*).

Cranberry False Blossom

The most serious cranberry disease in Massachusetts, New Jersey, and Wisconsin; known also on the Pacific Coast. American and European cranberries are the only natural hosts, but the virus has been dodder-transmitted to other plants. Cranberry flowers are erect, instead of pendent, with calyx lobes enlarged, petals short, streaked with red or green, stamens and pistils abnormal. Flowers may be replaced by leaves or short branches. Axillary buds produce numerous erect shoots forming witches' brooms; diseased fruits are small and irregular. Transmission is by the blunt-nosed leafhopper. Select strains resistant to the vector or flood the bogs after leafhoppers have hatched. Spray with pyrethrum.

Crimson Clover Latent Nepovirus

Symptomless on *Trifolium incarnatum*.

Cucumber Mosaic Cucumovirus

General with many strains in cucumber, squash, melon, winged bean, periwinkle, wild violets, desert-rose, and a wide range of other plants, including spinach, where the disease is called blight; tomato, causing shoestring disease with filiform leaflets; pepper, petunia, grlic mustard, fuschia, and tobacco. Wintering is on ground cherry, milkweed, pokeweed, catnip, Texas bluebell and *Peristroph* sp. and other weed hosts. Transmission is by peach, cotton, potato, and lily aphids and, in some cases, through seed.

In cucurbits there is a yellow-green systemic mottling, with leaves small, distorted, curled, plants dwarfed with shortened internodes, few fruits set and those mottled and misshaped, a condition called "white pickle." The lily mosaic strain produces a masked infection or chlorotic mottling and necrosis when mixed with Lily Symptomless Virus. The lima-bean, southern celery mosaic, and cowpea strains cause chlorotic mottling.

Geraniums are stunted and mottled; gladiolus flowers are color-broken; dahlia foliage has oakleaf patterns; periwinkle (myrtle) has a streaky mottle, down-curved leaves, small flowers with a white streak in the blue color. Petunias have distorted leaf blades, few or no blossoms. In delphinium, which is very susceptible, the disease is called ring spot, stunt, witches' broom.

Control. Resistant varieties of spinach, cucumber, and squash are available. Diseased lilies and other flowers should be rogued immediately. Control aphids by systemic ground treatments or sprays; repel aphid vectors by an aluminum foil mulch. Lilies may possibly be freed of the virus by scale propagation.

Cucurbit Leaf Curl Begomovirus

On pumpkin, cucumber, muskmelon, honeydew, zucchini, banana squash, and squash.

Cucurbit Leaf Crumple Begomovirus

On cucumber.

Cucurbit Yellow Stunting Crinivirus

On melon.

Currant (Red) Mosaic = Tomato Ringspot Nepovirus

Irregular, light green circular spots along midrib and larger veins enlarge to bands. Canes are stunted; plants decline.

Cymbidium Mosaic Potexvirus

Virus was isolated from many orchid species showing mosaic symptoms. It is transmitted by contact between plants.

Dahlia Mosaic Caulimovirus; Stunt

General. Bands along midrib and veins remain yellow-green. In some varieties leaves are distorted and blistered; in others, leaves are yellowed with margins up-rolled; in others, plants are very short and bushy with short flower stems. Transmission is by peach and other aphids.

Dahlia Oakleaf

May be a separate entity or a strain of Tomato Spotted Wilt Tospovirus. A pale chlorotic line across the leaf suggests the outline of an oak leaf.

Dahlia Ring Spot

Caused by a strain of Tomato Spotted Wilt Virus Tospovirus. Leaves have concentric rings or irregular zigzag markings. In Utah a yellow strain causes bright yellow rings and zigzags.

Dasheen Mosaic Potyvirus

Widespread in plants from Araceae family.

Delphinium Ring Spot

Faint chlorotic rings around green and yellow centers appear on young leaves, irregular necrotic spots or rings with yellow bands on mature leaves.

Desmodium Mosaic Potyvirus

Transmitted by aphids, sap and seeds. Leaf sap contains only a few filamentous (775 nm length) virus particles.

Desmodium Yellow Mottle Tymovirus

Transmitted by mechanical inoculation. Leaf sap contains many isometric (30 nm diameter) virions.

Diodia Vein Chlorosis Closterovirus

Transmitted by *Trialeurodes abultilonea*; caused chlorotic vein banding and chlorosis of *Diodia virgianiana* plants.

Dodder Latent Mosaic

Three species of dodder transmit mosaic to cantaloupe, potato, tomato, and celery.

Dogwood Mosaic Nepovirus

Considered earlier as a strain of Arabis Mosaic Nepovirus.

Elderberry Disease = Elderberry Carlavirus, Elderberry Latent Carmovirus

A virus disease reported from golden elderberry can infect various stone fruits and is considered a potential threat to the fruit industry.

Elm Mosaic

On American elm in Ohio and eastern states. Some leaves are larger than normal, others small, distorted, with yellow and green mottling. There may be some branch brooming, gradual decline in vigor. Transmission is by grafting; no insect vector is known.

Elm Zonate Canker

On American elm, New Jersey, Ohio, Missouri. Zonate cankers appear in bark as rings of dead and living tissue in cortex or phloem. Some leaves develop brown necrotic spots. Transmission is by bark patch grafts; no insect vector is known.

Euonymus Mosaic

Infectious Variegation. Persistent yellowing along veins; transmission by grafting and budding.

Euphorbia Mosaic Begiminivirus

Spreads in Florida by nymphs and adults of *Bemisia tabaci*. Infected plants showed mosaic and leaf malformation.

Fig Mosaic

Systemic chlorotic mottling is accompanied by severe leaf distortion; fruits have light circular areas or rusty spots, may be deformed and drop prematurely. Transmission is by grafting and the fig midge (*Aceria ficus*).

Figwort Mosaic Caulimovirus

The viral DNA has little homology with that of Cauliflower Mosaic Caulimovirus.

Filaree Red Leaf Luteovirus

On *Erodium* in California. Early symptoms are mild vein clearing, outward curvature of petioles, inward cupping of leaflets. Later leaflets cup outward, with reddish discoloration, are brittle, with petioles stiffly upright; flowers are dwarfed or suppressed. Aphids are vectors. Caused vein clearing and chlorosis of young leaves; older leaves are red and breakable. Infected plants are stunted and do not develop flowers.

Foxtail Mosaic Potexvirus

Virus related to Narcissus Mosaic and Viola Mottle Potexvirus.

Geranium Chlorotic Spot

General on geranium. It is caused by tomato and tobacco ring spot nepoviruses.

Geranium Crinkle

Pelargonium Leaf Curl Tombusvirus. General on geranium. Hyaline spots are small, circular to irregular, sometimes star- or tree-shaped, with brown centers. Young leaves are crinkled, small, sometimes puckered and split; severely infected leaves turn yellow and drop. Petioles and stems have corky, raised necrotic streaks; tops may die. The disease is most severe in spring, inconspicuous in summer. Transmission is by grafting (not by knife preparing cuttings) and probably by whiteflies.

Geranium (Pelargonium) Mosaic

Leaf Breaking. Leaves smaller, with purple spotting along veins, and suppression of horseshoe pattern in foliage of some geranium varieties.

Gladiolus Mosaic

► Bean Yellow Mosaic Potyvirus.

Grapevine Fanleaf Nepovirus

Infectious degeneration in California; Court-noué and Roncet in Europe. New growth is severely stunted; leaves are dwarfed and puckered or with deep indentations and folded like a half-closed fan; fruit set is poor. The virus is present in soil and can be transmitted, apparently, by nematodes.

Grapevine Fleck Virus

Generally symptomless in most cultivars; transmitted only by grafting.

Grapevine Rupestris Vein Feathering Marafivirus

On grape.

Grape Leaf Roll = Grapevine Leafroll-Associated Closterovirus

White Emperor Disease. In California, restricted to Emperor variety. Fruit is greenish yellow or pink rather than normal red; leaves are darker than normal, turning bronze or reddish along veins, yellow between veins.

Grapevine Stem Pitting Associated Chlosterovirus

Virions (800 nm length) found in phloem, but they are very difficult to extract from host tissue. Virus related only to Citrus Tristeza Closterovirus.

Grape Yellow Mosaic F Strain of Grapevine Fanleaf Nepovirus (Panachure)

Yellowing of leaves of young shoots in some varieties; various types of leaf mottling; blossom shedding. Transmission by grafting and in soil.

Grape Yellow Vein = Tomato Ringspot Nepovirus

Can be transmitted by dagger nematodes.

Guar Symptomless Potyvirus

Symptomless or caused mild green mottle on *Cyanopsis tetregonoloba*.

Hellenium S. Carlavirus

Hellenium and Impatiens strains differ in host range and aphid transmissibility.

Henbane Mosaic

Clearing or yellowing of veins of youngest leaves, then a yellow mosaic and dark green vein banding.

Hibiscus Chlorotic Ringspot Carmovirus

Caused very variable symptoms on the leaves of *Hibiscus rosa-sinensis*; from mottling and chlorotic spots to vein banding and rings.

Hibiscus Latent Fort Pierce Tobamovirus

On *Hibiscus*.

Hippeastrum Mosaic Potyvirus

Virus known also as Amaryllis Mosaic Virus, caused chlorotic streaking on leaves and flower stalks.

Hollyhock Mosaic

Pronounced yellow and green mottle on hollyhock and malva.

Holodiscus Witches' Broom

On ocean spray. Diseased branches form clusters of thin, wiry shoots with abnormally short internodes, crowded small leaves; foliage turns bronze red early. Transmission by the spirea aphid and by grafting.

Hop American Latent Carlavirus, Hop Latent Carlavirus, Hop Mosaic Carlavirus

All three carlaviruses are distantly serologically related. Usually they are symptomless or show mild mosaics.

Hyacinth Mosaic Potyvirus

Spreads by aphids. Virus caused chlorotic spots on leaves, stunt and color-breaking of flowers.

Hydrangea Latent Carlavirus

Reported on *Hydrangea macrophylla* in U.S.A.

Hydrangea Phyllody Phytoplasma

Witches' Broom, "green" flowers.

Hydrangea Ring Spot Potexvirus

Chlorotic blotches and rings, brown rings and oak-leaf patterns are common in florist's hydrangea. A probable cause of hydrangea "running out." Transmission is by cutting knife. Virus can infect snapdragon, sweet william and globe amaranth.

Iris Fulva Mosaic Potyvirus and Iris Severe Mosaic Potyvirus

Both potyviruses are spread generally by aphids. For diagnostic purposes they can be easily separated by pinwheel inclusions morphology.

Iris Mosaic = Iris Mild Mosaic Potyvirus

Widespread on bulbous iris, especially serious on Pacific Coast. Plants are stunted with yellowish streaks on leaves and dark, teardrop markings on white, blue, or lavender flowers, clear feathery markings on yellow flowers. Transmission is by peach and potato aphids. Establish disease-free foundation stock; rogue all diseased plants; spray for aphids.

Iris Yellow Spot Tospovirus

On *Allium* sp. Including *A. cepa*.

Impatiens Latent Potexvirus

Symptomless virus transmitted only by mechanical inoculation.

Impatiens Necrotic Spot Tospovirus

Previously called strain of Tomato Spotted Wilt Tospovirus. It is the most common and most damaging virus in the greenhouse industry. The virus has an extremely broad host range and its vector, the western flower thrips, *Frankliniella occidentalis*, are widespread and difficult to control. Symptoms caused by virus were variable but generally occurred as brown or black necrotic spots, blotch, necrotic rings on leaves and flower distortion. Often the center leaves collapse. Infected plants are stunted and die prematurely. The control of vector is essential in greenhouses.

Ixia Mosaic

Perhaps iris mosaic.

Johnsongrass Mosaic Potyvirus

Known also as Maize Dwarf Mosaic Virus strains 0 and Kansas and as Sugarcane Mosaic Virus. On Johnsongrass virus caused systemic mosaics.

Kalanchoe Top-Spotting Badnavirus

Kalanchoe blosfeldiana plants showed sunken yellow spots and sometimes leaf deformation.

Laburnum Mosaic

Infectious variegation. Bright mottling of foliage, often with veins picked out in yellow.

Lettuce Big Vein Varicosavirus

Transmitted by a vector-fungus, *Olpidium brassicae*. Vein clearing followed by enlarging and bleaching

Lettuce Infectious Yellows Closterovirus

Virus infected lettuce, sugarbeets, cantaloupe, watermelons, melons, squash, and carrots. Main symptoms included chlorosis, reddening and brittle leaves; plants stunted.

Lettuce Speckles Mottle Umbravirus

Virus in mixed infection is encapsidated in coat protein of Beet Western Yellows Luteovirus.

Lettuce Mosaic Potyvirus

Widespread on lettuce. Leaves mottled, deformed, yellowed, browned; plants stunted or dead. Transmission is by peach and root aphids and in seed. Control vectors, use virus-free seed; rogue seedbeds.

Lilac Mottle Carlavirus

Caused leaf chlorosis and mottling on *Syringa* spp.

Lilac Ring Spot Carlavirus

Pale green to yellow spots, lines, broad diffuse rings, and bands on lilac leaves, often with distortion and holes in tissue.

Lilac Witches' Broom Phytoplasma

On lilac, privet in Maryland. Brooming symptoms; lateral buds produce two to six slender shoots, which branch freely, with very small leaves on Japanese lilac. In common lilac and Regal privet there is yellow vein clearing with less prominent brooming. Transmission by grafting, and by dodder; no insect vector known.

Lily Color Adding

On lily.

Lily Color Removing

On lily.

Lily Fleck

Caused by Lily Symptomless Carlavirus and Cucumber Mosaic Cucumovirus. Yellow flecks on Easter lily leaves change to gray or brown, elongating parallel to veins; surface is depressed but unbroken. Plants are dwarfed with curled leaves, flowers small with brown streaks.

Lily Latent Mosaic

In Easter lily and tulip, symptoms masked or systemic chlorotic mottling.

Lily Mottle Potyvirus

It is a lily strain of Tulip Breaking Potyvirus.

Lily Ring Spot = Cucumber Mosaic Cucumovirus

Possibly a form of cucumber mosaic. There is only a faint mottling on some species, but on *Lilium tigrinum* and *L. regale* dark ring markings develop into necrotic areas. The growing point is killed; no flowers are formed; whole plant is twisted, stunted, deformed. Peach aphid is the vector.

Lily Rosette

Yellow Flat. On Easter lily. Leaves curl downward; plants are dwarfed, yellowed, mature early; bulbs are small. Transmission by the melon aphid, not by seed. Rogue diseased plants; spray for aphids.

Lily Symptomless Carlavirus

Present in Easter lilies wherever grown commercially but producing no symptoms alone; in combination with Cucumber Mosaic Cucumovirus causing necrotic fleck. Transmission by melon aphid.

Locust Witches' Broom

Brooming disease on locust from Pennsylvania to Georgia, Ohio, and Tennessee. Vein clearing is followed by reduction in size of new leaves, growth of spindly shoots to witches' brooms. Roots are more brittle, shorter, and darker than normal; rootlets branch excessively to root brooms. Transmission is by budding and grafting; no insect vector is known.

Loganberry Dwarf

Blackberry Dwarf. On loganberry and phenomenal blackberry in Northwest. Leaves are small, obovate, rigid, with new canes short and spindly. Young plants have crinkled leaves with some chlorosis or necrosis along veins. Flowers are small, drupelets ripen unevenly and tend to fall apart when fruit is picked. Transmission is by aphids.

Lolium Latent Potexvirus

On ryegrass (*Lolium perenne* and *L. multiflorum*).

Lonicera Infectious Variegation

Vein yellowing and variegation on honeysuckle; graft-transmitted.

Maize Dwarf Mosaic Potyvirus

First noted in Ohio in 1962 and since devastating to corn in many states. Red to purple streaks in upper leaves, ears usually incomplete; plants dwarfed with great reduction in yield. Transmission by corn leaf and peach aphids. Occurs also on *Sorghum* sp. and *Triticum* sp.

Maize Chlorotic Mottle Machlovirus

Usually occurred together with many potyviruses on infected maize plants showing severe systemic necrosis and stunting. Plant often dying.

Maize Rayado Fino Marafivirus

Initially described as a strain of Corn Stunt Virus now in the type species of Marafivirus. Virus frequently occurred in mixed infection with Phytoplasmas. It is multiplied in the vector, *Dalbulus maydis*, Cocadellidae and is not transmitted by sap, grafting or seeds.

Maize Stripe Tenuivirus

Caused yellow striping and chlorosis on natural hosts. *Zea mays, Sorghum vulgare, S. bicolor, Triticum aestivum* and *Hordeum vulgare*.

Maize Stunt = Maize Chlorotic Dwarf Waikavirus

► Corn Stunt.

Maize White Line Mosaic

On field corn and weed hosts including *Panicum, Setaria* and *Digitaria*.

Malva Vein Clearing Potyvirus

Caused vein clearing and yellow mosaics on many *Malva* and *Lavatera* species. Virus is known as Malva Mosaic, Malva Green Mosaic or Malva Yellow Vein Mosaic Virus.

Melon Leaf Curl Bigeminivirus

Caused leaf mottling and chlorosis on Cucurbits.

Melon Necrotic Spot Carmovirus

Transmitted by fungus *Olpidium radical*, by sap, by contact between plants and by seeds. It caused chlorotic and necrotic spots on Cucurbits.

Mimosa Striped Chlorosis Badnavirus

Infected *Albizzia* sp. plant showed chlorotic stripes along leaf vein and inter-veinal chlorosis.

Mint Crinkle Closterovirus

On golden ginger mint.

Mirabilis Mosaic Caulimovirus

Genome consists of DNA, virus-transmitted in semi-persistent manner by aphid, *Myzus persicae* and by sap.

Muskmelon Mosaic = Squash Mosaic Comovirus

Widespread on melon. First leaves have dark green bands parallel with main leaf veins; later leaves are mottled, sometimes deformed. Transmitted by seed and sap; insect vectors unknown

Muskmelon Vein Necrosis Carlavirus

Caused vein necrosis and leaf chlorosis on cucumber and pea plants.

Mustard Mosaic

On black mustard, California. Small, brown local lesions are followed by a general mottling.

Nandina Mosaic Potexvirus

Occurs in California; transmitted by mechanical inoculation.

Narcissus Chocolate Spot

Often present with white streak in a decline complex.

Narcissus Flower Streak

Strong breaking of flowers but normal foliage in Oregon bulb crops.

Narcissus Mosaic Potexvirus

Widespread on narcissus, but with mild symptoms, seldom apparent before plants bloom; has been confused with yellow stripe.

Narcissus White Streak

Silver Leaf. Paper tips and white streaks in leaves are primary symptoms, with wilting and falling over of foliage long before harvest so bulbs are small.

Causes decline combined with chocolate spot. Transmission by aphids. Replant only the largest bulbs.

Narcissus Yellow Stripe Potyvirus

Strong yellow streaking and mottling of foliage, often roughened near veins and with a peculiar twist. Flowers are streaked. Transmission by several species of aphids. Select the best plants for a mother block, with final selection during bloom; rogue plantings early before symptoms are masked by hot weather.

Nasturtium Mosaic Potyvirus

Vein clearing, ruffling and cupping of young leaves, dark green vein banding in older leaves, sometimes chlorotic spots or white rings between veins. Flower color may be broken, petals crinkled. Transmitted by several aphids.

Nothoscordum Mosaic Potyvirus

False garlic (wild amaryllis) mosaic transmitted through bulbs but not seed. Typical mosaic mottling of foliage.

Oak Ringspot Virus

Caused mosaic, chlorotic ringspot and oak leaf pattern on the older leaves.

Oat Blue Dwarf Marafivirus

Synonym for Flax Crinkle Virus transmitted by aster leafhopper. Infected *Avena* sp. plants turned deep blue.

Oat Golden Stripe Furovirus

Transmitted by fungus, *Polymyxa graminis*; systemically infected *Avena* sp. plants.

Oat Mosaic Bymovirus

Only *Avena* sp. are susceptible (developing mottle). Virus transmitted by fungus, *Polymyxa graminis*.

Odontoglossum Ringspot Tobamovirus

It is synonym for orchid strain of Tobacco Mosaic Tobamovirus.

Onion Yellow Dwarf Potyvirus

Yellow streaks develop at base of leaves, with yellowing crinkling, and flattening of new leaves. Leaves may be prostrate, flower stalks bent, twisted, and stunted; yield is reduced. Some species are relatively tolerant; tree onions are symptomless. Bean, apple-grain, corn leaf, and other aphids are vectors. Control is by indexing, growing sample lots of sets and mother bulbs in greenhouse beds or production of virus-free stocks in areas where disease is absent, and roguing of infected volunteer onions. Some varieties are resistant to the onion strain of the virus but not to the strain from shallot or garlic.

Opuntia Sammons' Tobamovirus

Symptomless on *Opuntia* spp., virus is transmitted only by mechanical inoculation.

Orchid (Cattleya) Blossom Brown Necrotic Streak

Brown spots, streaks of whole flower; leaves may have yellow streaks; transmission by knife. In removing flower spikes use "hot knife," with attached propane torch.

Orchid Fleck Rhabdovirus

Caused chlorotic and necrotic fleck on many orchid species. Virions are typical rhabdo or bullet-shaped.

Orchid (Cattleya) Mosaic Potexvirus

Flower-Break. On *Cattleya* and other orchids. There are apparently two diseases: mild color break, with variegation in the flower but no distortion, and severe color break, with flowers distorted or twisted as well as variegated. Leaves are mottled and sometimes twisted. The virus may be present in apparently healthy plants but can be detected with antisera, and infected plants removed. Transmission is by the green peach aphid.

Orchid (Cymbidium) Mosaic Potexvirus

Black Streak; Cattleya Leaf Necrosis. The most common virus disease on many kinds of orchids. On *Cymbidium* there is initially a mosaic mottle, then necrotic spots, streaks, and rings on leaves but no effect on flowers. In *Cattleya* there are sunken brown to black leaf patterns, sometimes rings, more often elongated streaks on older leaves. If leaves are killed prematurely, flowers are fewer and smaller but normal in form and color. No insect vector is known.

Orchid (Odontoglossum) Ring Spot Tobamovirus

On *Odontoglossum* only. Small, necrotic spots and rings on older leaves, light green to yellow areas on young leaves. Leaves may turn yellow and drop in 2 or 3 months or persist longer. There are no flower symptoms; no insect vector is known.

Orchid (Oncidium) Ring Spot

On mature leaves of *Oncidium*; round to irregular, slightly sunken yellow areas on both leaf surfaces; becoming necrotic with age.

Orchid (Vanda) Ring Spot

On 22 cultivated orchid species.

Ornithogalum Mosaic Potyvirus

On ornithogalum, galtonia, hyacinth, lachenalia, agapanthus, hebe, fine light and dark green leaf mottling becomes gray or yellow as leaves mature. Flower stalks are marked with light and dark green blotches; there are thin longitudinal streaks on perianth segments. Transmission is by melon, peach, potato and lily aphids.

Palm Mosaic Potyvirus

Infected *Washingtonia robusta* plants showed mosaics, ringspots and line pattern. Plants are often stunted.

Panicum Mosaic Sobemovirus

On St. Augustine grass.

Papaya Mosaic Potexvirus

Caused mosaic and stunting on *Carica papaya*.

Papaya Ringspot Potyvirus

Symptoms on infected *Carcia papaya* plants included mottling, malformation of leaves and streaking on flowers and fruits.

Pea Enation Mosaic Enamovirus

On pea, sweet pea, broad bean, soybean and sweet clover. Symptoms are yellowish spots on leaves, which are later white, with crinkling and savoying. Very susceptible varieties like Alderman have necrotic spots and proliferations or enations from underside of leaves. Pods may be markedly distorted and twisted with seeds small and yellow. Transmission is by pea, potato, and peach aphids.

Pea Mosaic Potyvirus

On pea, sweet pea, red clover and broad beans. Sweet pea has leaf mottling, chlorosis, breaking of flower color. Garden pea has vein clearing followed by mottling or general chlorosis and stunting. Transmission is by pea, peach and bean aphids. Perfection and Horal varieties are resistant to this virus but not to pea enation mosaic.

Pea Mottle

Pea Mottle caused by Clover Yellow Mosaic Potexvirus and Clover Yellow Vein Potyvirus. Fairly widespread on garden pea, snapbean, white clover and broad bean. On pea a severe systemic mosaic may be fatal. Some plants have chlorotic mottling of leaves and stipules, but stems, pods, and seeds are normal. Bean and pea aphids are probably vectors.

Pea Streak Carlavirus

Light brown to purple, oblong, necrotic lesions are scattered along stems and petioles with stems often girdled. Leaves and pods are roughened with light brown necrotic areas.

Pea Wilt

Causing severe streak in pea if pea-mottle virus is also present.

Peach Asteroid Spot

Discrete, chlorotic lesions spread along veins forming starlike spots; some chlorophyll is retained in lesions as leaves turn yellow.

Peach Calico

Leaves are first mottled, then yellowed, then papery white. Creamy white streaks develop on twigs. Fruit is shorter, rounder, with creamy white to red patches. Transmission is by budding.

Peach Dwarf

Only on Muir peach. Profusion of large, flat, dark green leaves, closely appressed on short twigs; witches' broom showing in dormant period; fruit larger than normal, misshapen.

Peach Golden Net

Probably identical with line pattern.

Peach Little Peach

Related to peach yellows, and in same host range, eastern United States.

Peach Mosaic

In Southwest on peach, apricot, nectarine, plum and capable of infecting almond. Spring growth of peach has short internodes, with sometimes flower breaking, chlorotic mottling, and foliage distortion early in the season, with masking of symptoms or dropping out of affected areas in midsummer. Fruit is small, irregular in shape, unsalable. Apricot stones have white rings and blotches. Transmission is by budding, grafting, a mite (*Eriophyes insidiosus*), and perhaps the plum aphid. Removal of infected trees, nursery inspection and quarantine reduce the incidence of mosaic.

Peach Mottle

Known only in Idaho.

Peach Necrotic Leaf Spot

On peach but with sweet cherry as a symptomless carrier. Light brown, dead, membranous areas in unfolding leaves fall out, leaving holes. The disease is recurrent on peach.

Peach Phony Disease

The most important peach disease in the Southeast. Trees are dwarfed; foliage is abnormally green, fruit small; there are flecks in wood, especially in roots. Phony trees have short terminal and lateral twigs; profuse lateral branching. Growth starts in spring earlier than on normal trees. Production gradually decreases, with trees worthless in a few years. Transmission is by root grafting and sharpshooter leafhoppers. Control has been by eradication and by quarantine to restrict movement of nursery stock.

Peach Red Suture

Probably a form of yellows. On peach and Japanese plum. Fruit ripens prematurely with softening, swelling, and red blotching on the suture, flesh coarse and watery while rest of fruit is hard and green. Eradicate diseased trees; propagate from healthy budwood.

Peach Ring Spot Ilarvirus

► Cherry Ring Spot.

Peach Rosette

On peach and plum. Trees suddenly wilt and die, or there are abnormally short stems bearing dwarfed leaves, with veins cleared and thickened; death follows in a few months. The virus can be inactivated by heating at 122°F for 10 minutes.

Peach Rosette Mosaic Nepovirus

Of minor importance on peach, highbush blueberry, and plum. Delayed foliation, chlorotic mottling, rosetting of shoots, dark green color; transmission by grafting and through soil. Eradicate trees; do not replant in same soil without fumigation.

Peach Stubby Twig

A new disease of peach and nectarine in California. Chlorotic leaves, stubby twig growth, decreased fruit production; transmitted with infected budwood.

Peach Wart

Foliage is normal but fruits are blistered, welted, and have conspicuous raised warty outgrowths. Tissues are light tan to red, rough, cracked, and russeted or smooth, with severe gumming. Transmission by budding or inarching.

Peach Yellow Bud = Tomato Ringspot Nepovirus

Winter's Peach Mosaic. On peach, apricot and almond in California. Pale yellow, feather-edged blotches along the midvein with leaf distortion, and defoliation near base of shoots. Transmission is by grafting. In field spread is only to adjacent trees, perhaps through soil.

Peanut Mottle Potyvirus

On wild peanut (*Arachis chacoense*).

Peanut Stunt Cucumovirus

First noted on peanuts in Virginia in 1964 and also occurs in bean, red and white clover. Severe dwarfing and malformation of foliar parts and suppression of fruit development. Transmission by grafting and green peach aphid.

Peanut Top Paralysis Potyvirus

Found in Oklahoma but there is no evidence of spread.

Pear Decline Phytoplasma

A relatively new and devastating disease in California, Oregon, and Washington, trees showing a slow decline or rapid collapse. First thought due to a toxin of the pear psylla (*Psylla pyricola*), now considered a virus disease transmitted by the psylla.

Pear Stony Pit

On Bosc and other pears in Pacific Northwest. Dark green areas appear just beneath epidermis of fruit, 10 to 20 days after petal fall, resulting in deeply pitted or deformed fruit at maturity, with corky or necrotic hard tissue at base of pits. The fruit is gnarled, hard to cut. Transmission is by grafting; no insect vector is known. Bosc and Anjou pears can be top-worked with Bartlett to reduce losses from stony pit.

Pelargonium Flower Break Carmovirus and Pelargonium Line Pattern Carmovirus

Viruses are usually symptomless on *Pelargonium* or caused by flower streaking, line pattern or chlorotic spotting. They are transmitted by grafting and by contact between plants.

Peony Leaf Curl

Plants half normal height, with crooked flower stalks, curled leaves. Transmission is by grafting but not contact; no insect vector is known.

Peony Ring Spot = Tobacco Rattle Tobravirus

Marked yellow mosaic, irregular or in rings, sometimes small necrotic spots.

Peperomia Ring Spot

Concentric brown, necrotic rings on leaves, which may be cupped, curled, or twisted and may fall. Severely affected plants are stunted. Grower losses in Florida may be 25%. Take cuttings from healthy, vigorous plants.

Pepper Mild Mottle Tobamovirus

Infectious virus particles were found in water for greenhouse irrigations.

Pepper Mild Tigre' Bigeminivirus and Pepper Texas Bigeminivirus

Both viruses are transmitted by *Bemisia tabaci* and spread in Texas and Mexico.

Pepper Strain of Alfalfa Mosaic

On pepper.

Pepper Vein Banding Mosaic

Probably caused by Potato Y Potyvirus, a new disease in Florida. Plants are stunted with up to 50% loss of marketable fruit. Vein clearing and banding on leaves, fruit roughened with chlorotic spots or stripes. Transmission is by green peach and melon aphids. Eradicate deadly nightshade as a weed host for 150 feet from peppers, or use sunflower as a barrier.

Pepper Mottle Potyvirus

On pepper.

Phlox Streak

Streaks evident in leaves and stems. Clearing of veins is followed by necrosis in leaf veins and petioles. Graft-transmissible.

Physalis Mosaic Tymovirus

Known as Belladonna Mottle Virus caused by systemic mosaic or mottle.

Pigeon Pea Golden Mosaic Begomovirus

On pigeon pea.

Pineapple Wilt – Associated Closterovirus

Occurs in the Hawaiian pineapples causing yellowing and flecks on leaves, leaf tip necrosis and plant wilt.

Plantago Mottle Tymovirus

Related to Andean Potato Latent, Dulcamara Mottle, Belladonna Mottle, Onion Yellow Mosaic and Turnip Yellow Mosaic Viruses.

Plum Line Pattern = Plum American Line Pattern Ilarvirus

On plum, oriental cherry, widespread. Some plum varieties have yellow vein banding, brilliant green and yellow patterns of the oakleaf type, formed by single or multiple irregular lines or bands; in early summer the yellow fades to creamy white. In other varieties patterns are faint or absent. On flowering cherries discolored areas are bounded by a chlorotic band. Transmission is by budding or grafting.

Plum White Spot

Small pale yellow to white spots, mostly aggregated near leaf tips on Santa Rosa plum.

Poinsettia Mosaic Tymovirus

Caused systemic leaf mosaic and malformation and discoloration of bracts.

Poplar Decline Potyvirus

Pinwheel structures are induced in infected cells. Main disease symptoms are chlorotic and necrotic leafspots, necrosis of leaves and death of branches and even whole trees.

Poplar Mosaic Carlavirus

Many cultivars are symptomless or they develop mosaics or necrosis. Virus usually occurs alone in infected poplar trees.

Potato A Potyvirus

Known as Potato Mild Mosaic, Potato Virus P and Solanum Virus 3. Transmitted by aphids in non-persistent manner. Virus caused no symptoms.

Potato Acropetal Necrosis

Caused by potato viruses Y and X.

Potato Aucuba Mosaic Potexvirus

Bright yellow mottle in most varieties, sometimes necrosis of tubers.

Potato Bouquet Disease

Caused by Tobacco Ring Spot Nepovirus.

Potato Calico

Caused by strain of Alfalfa\Mosaic Alfamovirus.

Potato Crinkle

Mild Mosaic. Due to Potato Virus X plus A. Leaf mottling and crinkling are often inconspicuous, but plants die prematurely. Plant healthy tubers; isolate seed plots. Varieties Katahdin, Chippewa, Houma and Sebago are resistant.

Potato Green Dwarf

Caused by a strain of Beet Curly Top Hybrigeminivirus. Terminal growth is dwarfed and deformed; leaflets cupped upward.

Potato Leaf Roll Luteovirus

Important wherever potatoes are grown. Symptoms show about a month after plants appear above ground. Leaves are thick, leathery, rolled, with excessive starch; sometimes with a reddish or purple discoloration on the underside. Plants are dwarfed; tubers are few, crisp, with net necrosis – brown strands of dead tissue – in some varieties; sprouts are spindling; yield may be reduced one-half. Transmission is by peach and other aphids.

Use certified seed potatoes. These come from a foundation stock obtained by indexing. Seedpieces or tubers are planted consecutively in a row, and if any show virus symptoms, the whole unit is destroyed.

Potato Leaf Rolling Mosaic = Potato M Carlavirus

Leaves are mottled, flaccid, with some upward rolling but without distinct rolling, rigidity of leaf roll. Transmission by peach, potato and geranium aphids.

Potato Mottle

Caused by potato X potexvirus.

Potato Rugose Mosaic

Caused by potato Y potyvirus, often with PVX. Leaves are crinkled, mottled; lower leaves with black veins; plants are stunted, die prematurely. Control by careful roguing.

Potato S Carlavirus

Generally symptomless in most potato cultivars.

Potato Spindle Tuber Viroid

General on all tested varieties of potatoes. Plants are more erect than normal but spindly, lacking vigor. Stems are stiff, leaves small, dark green; tubers are elongated, pointed at the end, the eyes “staring”. Symptoms are accentuated by high soil moistures. Transmission is by contaminated knives in cutting, by contact between freshly cut seed pieces. Control by using certified seed.

Potato Vein Banding = Potato Y Potyvirus

On potato and many other hosts, transmitted mechanically and by many aphids. On some varieties there is leaf drop and necrotic streak or chlorotic mottling; on others there is no sign of disease.

Potato Virus A

Present in nearly symptomless form in some varieties, causing crinkle with virus X.

Potato X Potexvirus

Almost universally present in commercial potato stocks. Cause of latent mosaic.

Potato Witches’ Broom

Apical leaves are slightly rolled, upright, light green with reddish or yellowing margins. There is proliferation of axial buds with tendency to bloom and set fruit; there are aerial tubers and numerous small subterranean tubers. Such tubers put out spindle shoots without a rest period and produce dwarfed, very bushy plants with small, round, or heart-shaped leaves. Use certified seed potatoes.

Potato Yellow Dwarf Nucleorhabdovirus

Formerly causing heavy losses in Northeast but now mostly controlled by seed certification. Potato leaves are rolled and yellowed; the plant is dwarfed with split stems showing rusty flecks. Transmission is by clover leafhoppers; overwintering hosts are ground cherry, oxeye daisy, vinca and other plants.

Potato Yellow Spot

Reported from Maine, mostly on Katahdin variety. Spots are small, circular, bright yellow, chiefly on lower leaves.

Primrose Mosaic

Plants are chlorotic, stunted, rugose, with upward, sometimes downward, cupping of leaves. Petioles and peduncles are shortened; flowers are white-streaked; leaves are coarsely mottled yellow-green, with green islands; tips of leaves are narrowed. No insect vector is known.

Privet Ring Spot

Reported on privet in Texas. Leaves are smaller, lighter green, drop early.

Prune (Standard) Constricting Mosaic

Spots are concentrated in a band across tip of the leaf; this area is killed, and all tissue except the midvein drops out.

Prune Diamond Canker

Symptoms expressed only on French prune – diamond or oval excrescences on secondary branches, often excess sprouts from body of tree.

Prune Dwarf Ilarvirus

On prune, plum, cherry and peach. Leaves are small, narrow, rugose, distorted, glazed. Internodes are short, but some branches escape and appear normal. Blossoms are numerous, but mature fruits few; pistils are aborted, petals narrowed. Most injurious to Italian prune, symptomless in Bradshaw and damson plums. Transmission by grafting and budding.

Prunus Necrotic Ringspot Ilarvirus

Very common in sweet cherry and plum orchards, worldwide. Its natural hosts are species from *Prunus, Rosa, Humulus* and *Cucumis*. Earlier virus was described as Plum Line Pattern, Peach Ringspot, Prunus Ringspot, Red Currant Necrotic Ringspot, Rose Chlorotic Mottle, Rose Line Pattern, Rose Vein Banding and Sour Cherry Necrotic Ringspot. Virus is transmitted by grafting, by seeds and by pollen to seeds and to the pollinated plants.

Quail Pea Mosaic Comovirus

Caused mosaics on *Streptostyles helvola* as well as on soybean and common bean plants.

Radish Mosaic Comovirus

Chlorotic spotting and mottling of foliage; plants not stunted.

Ranunculus Mottle Potyvirus

Caused foliar mottling and distortion on *Ranunculus asiaticus* plants.

Raspberry Alpha Leaf Curl Luteovirus

Common on red raspberry. Veins are retarded in growth, causing downward curling and crinkling of leaves. Foliage is dark green, but bronzed in late summer with glistening surface. Berries are small, poor; diseased canes are readily winter-killed. Transmission is by small raspberry aphid (*Aphis rubiphila*). Cuthbert variety is most susceptible. Rogue diseased plants.

Raspberry Beta Leaf Curl Luteovirus

Infecting blackcaps, especially Cumberland, but also causing severe curling on Cuthbert and hybrid purple Columbian.

Raspberry Decline

On red raspberry.

Raspberry (Red) Mosaic

Green Mottle; Mild Mosaic; Yellows. Widespread on red and black raspberries, dewberry and blackberry. Symptoms vary greatly, but usually mottled areas are darker green than rest of leaf tissue; there may be blistering and curling downward. On blackcaps, tips are stunted, fruiting laterals shortened, fruit seedy or with poor flavor. Foliation of diseased plants is delayed. Transmission by aphids.

Raspberry (Black) Necrosis

On red and black raspberries and perhaps related to red raspberry mosaic. Leaves are curled down, have necrotic spots.

Raspberry Ringspot Nepovirus

Virus known also as Red Currant Ringspot is transmitted by nematode, *Longidorus* spp. Raspberry cultivars differ in susceptibility.

Raspberry Streak

Eastern Blue Streak, Rosette. On black raspberry. Plants are stunted, smaller in successive seasons, leaves usually curled, close together on canes, dark green, often twisted upside down. New canes have bluish dots or streaks near the base and sometimes on branches of fruiting spurs. Fruit is small, poor; plants are short-lived. Symptoms are less severe in the mild streak strain. Roguing aids in control.

Raspberry Yellow Mosaic = Rubus Yellow Net Bednavirus

Black raspberries are severely dwarfed; fruiting laterals are more upright than normal; foliage is yellow; leaflets are long and narrow. Symptoms show at high temperatures, while those of red raspberry mosaic are masked. Plants are weakened, die in 2 or 3 years. Transmitted by the raspberry aphid.

Red Clover Vein Mosaic Carlavirus

Caused vein yellowing and mosaic on infected red clover plants.

Rhododendron Necrotic Ringspot Potexvirus

Transmitted by grafting; infected *Rhododendron* spp. showed necrotic rings on leaves.

Rhubarb Chlorotic Ring Spot

Chlorotic spots and rings, necrotic stippling and rings on leaves of rhubarb, reported from Oregon.

Rhubarb Ring Spot

Caused by Turnip Mosaic Potyvirus.

Rhynchosia Golden Mosaic Begomovirus

Reported on soybean in Mexico.

Ribgrass Mosaic Tobamovirus

It is ribgrass strain of Tobacco Mosaic Tobamovirus.

Robinia Brooming

► Locust Witches' Broom.

Rose Mosaic

Infectious Chlorosis. Common on garden roses on the Pacific Coast, sometimes on greenhouse roses in the East and on garden roses originating in the West. Chlorotic areas feather away from midribs of leaflets, often with local distortion, sometimes with ring, oakleaf and watermark patterns. Plants are dwarfed, with buds often bleached, imperfect, on short stems. The virus is carried in understock and infects tops after budding or grafting; no insect vector is known. More than one virus is probably involved. Much rose mosaic seems to be due to the Prunus Necrotic Ring Spot and Apple Mosaic Ilarviruses. Rootstocks can be heat-treated to provide a virus-free source.

Rose Rosette

On species roses, Wyoming, California. Leaflets and flower parts are misshapen, stems dwarfed, with precocious growth of lateral buds, indefinite chlorotic pattern in leaves, increase in thorniness of stems. The general effect resembles 2, 4-D injury. Graft and mite transmissible, but the disease develops slowly.

Rose Streak

On rose in eastern United States. Leaves have brownish or reddish ring and vein-banding patterns; stems have ring patterns and sometimes necrotic areas near inserted buds, causing girdling, wilting of foliage. Transmission is by grafting.

Rose Yellow Mosaic

Chlorotic areas are brighter and lighter yellow than in typical rose mosaic; there is less puckering of leaves.

Saguaro Cactus Carmovirus

Symptomless on Saguaro cactus plants. Virus was found in Arizona but there is no evidence of spread.

Schefflera Ringspot Badnavirus

Bacciliform particles were found in *Brassica actinophylla*.

Shamrock Chlorotic Ringspot Potyvirus

Caused chlorotic Ringspot on leaves and decline of *Oxalis regnellii* plants.

Smithiana Potex Virus

Infected plants are usually symptomless.

Solanum Yellows Luteovirus

Occurs on potato plants.

Sonchus Yellow Net Nucleorhabdovirus

On lettuce.

Sorghum Chlorotic Spot Furovirus

Found only in Kansas; caused chlorotic spot on infected plants.

Sorghum Mosaic Potyvirus

Virus is one of the potyvirus complex infecting tropical grasses.

Sorghum Stunt Mosaic Nucleorhabdovirus

Transmitted by leafhopper, *Graminella sonora*, only in temperatures below 38°C.

Sowbane Mosaic Sobemovirus

Occurred in Europe, South and Central American region; found also in USA.

Sowthistle Yellow Vein Nucleorhabdovirus

Susceptible hosts are *Sonchus oleraceus* and *Lactuca sativa*.

Soybean Dwarf Luteovirus

There are two different strains of this virus; dwarfing strain and leaf yellowing strain. Virions occurred in cytoplasm and cell vacuoles of phloem. Virus transmitted only by aphid vectors in persistent manner.

Soybean Mosaic Potyvirus

Widespread on soybean. Leaves are distorted, narrow, with margins turning down, some with ruffling along main veins; plants are often stunted, pods misshapen with fewer seeds. Transmission by peach, pea and other aphids and in seed. Control by roguing.

Soybean Yellow Mosaic

Soybean Yellow Mosaic is caused by the Bean Yellow Mosaic Virus. Younger leaves show chlorotic mottling, followed by necrotic spots. Soybean bud blight, due to Tobacco Ring Spot Virus, is serious in the Midwest, causing losses up to 100%. Tip buds turn brown, dry brittle; plant is dwarfed, produces no seed.

Sparaxis Mosaic

Strong leaf mottling and crinkling.

Spinach Blight

Caused by Cucumber Mosaic Cucumovirus.

Spinach Latent Ilarvirus

Transmitted by means not involving a vector. Symptoms disappeared soon after infection.

Spinach Yellow Dwarf

In California, confined to spinach, with vein clearing, curvature of midrib; young leaves with mottling, puckering, curling, blisters; old leaves with yellow blotches becoming necrotic. All varieties are equally susceptible. Mechanical transmission and by aphids.

Spring Beauty Latent Bromovirus

Symptomless; best serological test for identification is double diffusion test.

Squash Leaf Curl Bigeminivirus

It is probably the same as Muskmelon Necrotic Mosaic Virus causing severe stunting and leaf curl on plants from family Cucurbitaceae.

Squash Mosaic Comovirus

On squash and muskmelon, mostly in California. Foliage is severely mottled and malformed with dark green blisters. Transmission by banded, western striped and 12-spotted cucumber beetles, but not by pollen.

Squash (Southern) Mosaic

On squash in Florida, infecting also cucumber and watermelon.

Stock Mosaic

On stock, reported from California. Definite mottling with dark green islands conspicuous against light green areas. Plants are stunted; seed pods small; flowers broken with petals undersized. Cut-flower fields are often a total loss, but there are resistant varieties.

Strawberry Crinkle Cytorhabdovirus

Chlorotic and necrotic spotting with crinkled leaves and vein clearing. Transmission by strawberry aphid.

Strawberry Latent Ringspot Nepovirus

Infects strawberry and rose; latent and seedborne in parsley.

Strawberry Latent Virus Rhabdovirus

Causing no distinct symptoms but intensifying those caused by other viruses.

Strawberry Leaf Curl

Caused by Strawberry Veinbanding Caulimovirus plus Strawberry Latent Rhabdovirus.

Strawberry Leaf Roll

Leaflets are rolled down, pale green, small, on spindly petioles.

Strawberry Mild Crinkle

Caused by Strawberry Vein Chlorosis Virus with or without Strawberry Mottle Virus.

Strawberry Mild Yellow Edge Chlorosis Potexvirus

Slight chlorosis of leaf margin.

Strawberry Mild Yellow Edge Luteovirus

Transmitted by aphids in persistent manner. The relation to Soybean Dwarf Luteovirus is so close that they are probably the same species.

Strawberry Mottle

Chlorotic spotting, leaf distortion.

Strawberry Multiplier Disease

Resembling witches' broom and stunt; transmitted by leaf grafting.

Strawberry Necrotic Shock = Tobacco Streak Ilarvirus

Blackish spots on leaves and petioles; whole crown may be killed, but plants recover, and virus becomes latent.

Strawberry Pallidosis = Cucurbit Yellows Crinovirus and Beet Pseudo-Yellows Closterovirus

On strawberry.

Strawberry Pallidosis Virus

Caused no disease symptoms and is transmitted only by grafting; dsRNA was found in infected cells.

Strawberry Phyllody Strawb PhF Phytoplasma

On strawberry.

Strawberry Pseudo Mild Yellow Edge Carlavirus

Symptomless on infected plants; transmitted by aphids in semi-persistent manner. Virus related to Carnation Latent Carlavirus.

Strawberry Severe Crinkle

Due to Strawberry Mottle Virus plus Strawberry Crinkle Cytorhabdovirus.

Strawberry Stunt

In the Pacific Northwest. Plants are erect but short; leaves at first folded, later open, dull with a papery rattle; leaflets cupped or with margins turned down;

midveins tortuous; petioles short; fruits small, hard, seedy. Transmission by the strawberry aphid.

Strawberry Veinbanding Caulimovirus

Diffuse banding along veins; leaflets with epinasty, mild crinkling, wavy margins. Transmission by several aphids, grafting, dodder.

Strawberry Witches' Broom

Leaves are numerous, light in color with spindly petioles; margins of leaflets are bent down; runners are shortened, plants dwarfed; flower stalks spindly and unfruitful. Transmission by the strawberry aphid.

Strawberry Yellow Edge

Central leaves dwarfed, with yellow edges.

Strawberry Yellows

A complex caused by mild yellow edge, crinkle, and mottle viruses. June yellows is a genetic leaf variegation, not due to a virus.
For control of strawberry viruses buy certified plants. Nurseries on the Maryland eastern shore provide 37 varieties virus-free from a foundation stock of indexed plants.

Streptanthera Mosaic

Mottled foliage. Caused by Bean Yellow Mosaic Virus.

Subterranean Clover Red Leaf Luteovirus

Caused mild yellowing, stunting and reddening of many plants from Leguminosae family.

Sugarcane Bacilliform Badnavirus

Occurs in Florida and Hawaii; serologically virus is related only to Banana Streak Badnavirus.

Sunflower Mosaic Potyvirus

Known also as Helianthus Mosaic Virus; caused mild systemic mosaic and mottling, sometimes necrosis on leaves and stems.

Sweet Clover Sweet Latent Nucleorhabdovirus

Virus often together with Bean Common Mosaic Potyvirus caused leaf chlorosis.

Sweet Potato Caulimovirus

There are no conspicuous symptoms on *Ipomoea batata*. There is no evidence of it spreading in the United States.

Sweet Potato Feathery Mottle Potyvirus

First symptom is a yellowing along veins or small diffuse yellow spots. Some leaves are abnormally dark green with feathery yellow areas along veins. Leaves may be slightly rugose and dwarfed. Transmitted by aphids, whiteflies, and sprouts. Caused feathering, clearing and chlorotic spots on *Ipomoea batata* but symptoms usually disappeared soon after infection.

Sweet Potato Internal Cork = Sweetpotato Feathery Mottle Potyvirus

First recognized in South Carolina in 1944, now in most sweetpotato areas, most prevalent in Georgia and the Carolinas. Dark brown to blackish corky spots in flesh of roots, which appear normal outside. Some are present when sweetpotatoes are dug, but cork spots increase in number and size during storage, especially at temperatures higher than the recommended 55° to 60°F. Foliage symptoms are vein feathering and mottling followed by reddish to purple blotching sometimes in ring form. Quality of Porto Rico variety is severely affected, but not yield. Transmission is by peach and potato aphids and by grafting, with morning-glories used as index plants. Control insects to reduce disease; there is little spread to new plantings 100 yards or more from diseased fields. Cure immediately after digging at 85°F with 90% humidity; then store at 55°F, except seed stocks, which should be kept at 70°F so that lots with internal cork can be selected and discarded.

Sweet Potato Mosaic

Transmitted by fleshy-core and sprout grafts and by sweetpotato whitefly.

Sweet Potato Russet Crack – Strain of Sweetpotato Feathery Mottle Potyvirus

Dark lesions and fine cracks in skin of fleshy roots.

Teasel Mosaic Potyvirus

On Fuller's teasel and scabiosa, with vein-clearing, asymmetry, strong mosaic pattern, malformation, death of plant. Transmission by peach and rose aphids.

Tigridia Mosaic

Pale to yellow-green irregular streaks and blotches in leaves and flower bracts, occasionally dark streaks in flowers. Transmission by lily and melon aphids.

Tobacco Broad Ring Spot

In tobacco, Wisconsin, experimentally to other plants. Chlorotic or necrotic rings, sometimes concentric; young leaves puckered at first.

Tobacco Etch Potyvirus

Mild and severe strains widespread on tobacco, tomato, pepper, petunia, potato and other plants. Symptoms are vein clearing with fine necrotic etching, usually toward base of leaves. Plants are stunted with smaller, mottled leaves. Transmission is by peach, lily, bean and other aphids.

Tobacco Mild Green Mosaic Tobamovirus

Transmitted on the surface of the affected seeds. Infectious virus particles were found in water used for irrigation in greenhouses.

Tobacco Mosaic Tobamovirus

Tomato Mosaic; Pepper Mosaic. General in gardens, fields, greenhouses on tobacco, tomato, pepper, eggplant, petunia, Moraine ash, *Achimenes, Aeschynanthus, Chirita, Codononthe, Episcia*, gloxiana, *Kohleria, Nematanthus, Streptocarpus, Smithantha, Rhoeo*, and nearly all solanaceous plants. Tomato foliage has a light and dark green mottling, accompanied by some curling and malformation of leaflets, often with a fernleaf effect. A yellow strain of the virus causes striking yellow mottling of leaves, sometimes stems and fruits. Yield is greatly reduced. In pepper, yellowish chlorotic lesions are followed by systemic chlorosis. Spinach has some mottling, stunting, necrosis. Eggplant is often killed.

Transmission is by mechanical means – by handling, on tools, through soil, by grafting, possibly but not probably by seed. The virus can be transmitted by feeding of grasshoppers, but apparently there is little spread by the usual aphid vectors. This is the most resistant and highly infectious of all viruses. It withstands heat, even alcohol and various germicides, and retains infectivity in a dried state for many years. The most common source of inoculum is smoking tobacco. Gardeners contaminate their hands by smoking and then infect plants as they transplant, tie, prune, etc., the virus entering through scratches or broken hairs. The first symptoms appear in 8 to 10 days. In greenhouses, even doorknobs, faucets, and flats can be contaminated after handling virus-infected plants and remain a source of infection.

There are many strains of the virus, causing cowpea mosaic, tomato aucuba mosaic, tomato enation mosaic, tomato streak, orchid aucuba, etc.

Control. Remove and burn any suspicious plants in the seedbed along with neighboring plants. Destroy weeds, especially ground cherry and other solanaceous species. Never smoke while working with plants, and always wash hands thoroughly with soap after handling tobacco in any form or touching diseased plants, before handling young seedlings or healthy plants.

Tobacco Necrosis Necrovirus

On tobacco, tomato, aster, geranium and bean, confined to roots, or systemic without symptoms, or systemic with symptoms. In Holland, the virus causes a severe crippling of tulips called Augusta disease, often preventing flowering, resulting in death.

Tobacco Rattle Tobravirus

On Romaine lettuce and transmitted by *Paratrichodorus christiei*.

Tobacco Ring Spot Nepovirus

General on tobacco, petunia, potato, cucumber, celery, Moraine ash and geranium, causing pimple disease of watermelon, bud blight of soy bean, in gladiolus, iris, Astilbe, and Easter lily without symptoms. Causing large chlorotic areas on spinach leaves; faint zigzag lines on beet; pin-point necrotic spots with yellow haloes on cucurbits and fruits first pitted, then with elevated pimples; eggplant yellows, “bouquet disease” of potatoes, with stems curved, shortened, sometimes with black lesions on underside of veins. Petunia seedlings are stunted, first leaves are mottled, and seed pods have few seeds. Mint is stunted.

Transmission is through seed of petunia (but not of tobacco), by nematodes and in some crops by grasshoppers.

Tobacco Streak Ilarvirus

On tobacco, soybean, sweet clover, tomato, common yellow mustard, wild radish, milk thistle, and experimentally a wide range of hosts. Irregular spots, lines, and rings. Distributed worldwide. Virus is known as Asparagus Stunt Virus, Datura Quercina Virus and Strawberry Necrotic Shock Virus. It is transmitted by thrips, by sap and by seeds. Virus is also transmitted by pollen to the pollinated plants.

Tobacco Vein Mottling Potyvirus

Transmitted by aphids in non-persistent manner. Its natural host plants are Rumex sp., *Nicotiana tabacum* and *Solanum carolinense*. Virus caused chlorotic vein banding symptoms on infected plants.

Tobacco Yellow Net Luteovirus

Spreads by aphids – *Myzus persicae* in California. Virus differs in host range from Beet Yellow Net Luteovirus.

Tomato Aspermy Cucumovirus

Chrysanthemum Aspermy. On tomato the growing point of the main stem is inhibited, axillary shoots giving the plants a bushy appearance; fruit production is curtailed; there may be failure to set seed. The disease was introduced into North America on European and Asiatic varieties of chrysanthemums, which have mottled leaves. Transmission is by foxglove, green peach, and green and black chrysanthemum aphids. Perennial chrysanthemums near tomato fields are a source of infection.

Tomato Big Bud

Leaves curl and hang down; stems are shortened and calyxes greatly enlarged.

Tomato Black Ring Nepovirus

Transmitted by nematodes, seeds and pollen. Virus caused necrotic ringspots, systemic chlorotic ringspots, mottling, stunting and leaf malformation of the following plant genera: *Allium, Apium, Beta, Fraxinus, Lactuca, Lycopersicon, Narcissus, Phaseolus, Robinia, Rubus, Solanum, Tulipa* and *Vitis*.

Tomato Bushy Stunt Tombusvirus

Strains of this virus are known as Carnation Italian Ringspot Tombusvirus, Pelargonium Leaf Curl Tombusvirus and Petunia Asteroid Mosaic Tombusvirus. Virus transmitted by means not involving vectors. Virions were found in all parts of the host plant: in cytoplasm, in nuclei, in nucleoli, in mitochondria and in cell vacuoles. It forms crystals in the cytoplasm.

Tomato Chino La Paz Begomovirus

Found on tomato in Baja California, Mexico.

Tomato Enation Mosaic

Caused by a strain of Tobacco Mosaic Tobamovirus.

Tomato Fernleaf

Shoestring. Caused by Cucumber Mosaic Cucumovirus sometimes with Tobacco Mosaic tobamovirus.

Tomato Infectious Chlorosis Closterovirus

Transmitted by white fly – *Trialeurodes vaporariorum*; caused interveinal yellowing and necrosis in infected tomato plants.

Tomato Mosaic Tobamovirus

Circular, water-soaked necrotic spots on leaves; black streaks on veins; concentric sunken rings on fruit.

Tomato Pseudo Curly Top Hybrigeminivirus

Spreads among tomato plants in Florida. Virus is transmitted by treehopper *Micrutalis malleifer*. Virion genome consists of circular ssDNA.

Tomato Ring Spot Nepovirus

Curling and extensive necrosis of shoot terminals; brown rings and streaks on leaflets, stems, fruits, more pronounced at high temperature. Causes leaf streaks in iris, crumbly fruit of red raspberry and chlorotic spot of geranium. May infect chicory, healall, black medic, moth mullein, impatiens, apple, common cinquefoil and dandelion. Transmission is by dagger nematodes.
Plants that may serve as reservoir plants for Tomato Ringspot Virus are: chickweed, henbit, dandelion, woodsorrel, plantain, strawberry, sorrel and red clover.

Tomato Spotted Wilt Tospovirus

More serious on the Pacific Coast, but also occurring in Florida, Texas and some central and eastern states in greenhouses and sometimes outdoors on plants such as ragwort, purslane, nightshade, desert-rose, and puncture vine. Spotted wilt is common on tomato, potato, tobacco, lettuce, pea, pepper, celery and other vegetables. Ornamentals include amaryllis, aster, begonia, blackberry-lily, calendula, calla, chrysanthemum, dahlia, delphinium, fuchsia, gaillardia, gloxinia, nasturtium, geranium, primrose, petunia, Rieger begonia, hydrangea, stephanotis, salvia, stock, verbena and zinnia.
In tomato there are bronze, ringlike secondary lesions; plants are stunted with some necrosis; there may be a yellowish mosaic with leaf distortion. Fruits are often marked with concentric rings of pale red, yellow, or white. Potatoes have zonate necrotic spots on upper leaves, streaks on stems, which collapse at the top; plants are stunted, with small yield. Lettuce is yellowed, with retarded growth, brown blemishes on central leaves; affected spots are like parchment but with brown margins. Peas have purplish necrotic spots on stems and leaves following mottling, and circular spots and wavy lines on pods. Spots on outer stalks of celery are first yellow, then necrotic with pockets of dead tissue inside petioles; plants are stunted and worthless.
China asters have dead tan areas in leaves, brown surface blotches on stems. Calla lillies have whitish, then brown spots and streaks. On sweet pea, reddish brown to purple streaks may run full length of the stem. Circular to oval leaf spots with diffuse margins are followed by yellowing and death of leaves and stems. Blossoms sometimes develop a circular pattern in the pigment. Delphiniums may have numerous distinct double rings. The viruses

causing oak leaf and ring spot in dahlia are probably strains of the spotted wilt virus.
Transmission is by onion and flower thrips. Only the larvae can become viruliferous by feeding on infected plants, but then there is an incubation period of 5 to 9 days, during which the insect becomes adult, before the virus can be transmitted to healthy plants.

Tomato Streak; Double Streak

Caused by Tobacco Mosaic Tobamovirus plus Potato X Potexvirus. Leaves are mottled green with numerous small, grayish brown papery spots, may wither and dry. Later growth is mottled green and yellow with small chocolate brown spots and dark brown streaks on stems; fruit has brown greasy spots. The disease is more important in greenhouses; workers should refrain from handling tobacco or potatoes while working with tomatoes.

Tomato Top Necrosis Neopvirus

Occurs in Indiana, Missouri and Illinois. Virus is very rare on tomato plantations. It is serologically related to many nepoviruses.

Tomato Western Yellow Blight

► Beet Curly Top Hybrigeminivirus.

Tomato Yellow Leaf Curl Begomovirus

On tomato.

Tomato Yellow Net = Tobacco Yellow Net Luteovirus

Pronounced yellow necrosis of veins and veinlets. Transmission by the peach aphid.

Tomato Yellow Top = Strain of Potato Leafroll Luteovirus

Leaflets small, curled, yellow; or purplish in cool weather.

Tradescantia – Zebrina Potyvirus

Transmitted by aphids to *Tradescantia, Zebrina, Commelina* and *Rhoeo* sp. plants on which it caused mosaics, stuntings and malformation of leaves.

Tritonia Mosaic

Mottling at base of young leaves.

Tulare Apple Mosaic Ilarvirus

Caused leaf chlorosis on *Corylus* and *Malus* sp., it is transmitted only by mechanical inoculation. Virus is related to Citrus Leaf Rugose Ilarvirus.

Tulip Breaking Potyvirus

Due to Lily Latent Mosaic virus often present with Tulip Color-adding virus. Broken tulips appear wherever hybrids are grown. There is little or no obvious effect on foliage and little interference with growth, but there are marked color patterns on the flowers; differences in named broken varieties possibly due to the proportion of color-breaking and color-adding viruses present. Most pure white flowers do not change; some turn pink or red. Pink and bright red flowers have strong color changes; very dark tulips turn even darker. There may be dark stripes due to pigment intensification. Transmission is by aphids, and roguing should take place early, before insects are active. Broken varieties should not be grown near those with solid colors.

Turnip Mosaic Potyvirus

Cabbage Black Ring Spot; Watercress Mottle; Nasturtium Mosaic. On turnip, rutabaga, rape, mustard, cabbage, collard, horse-radish, watercress, garden balsam, nasturtium, stock, lady's slipper, impatien, safflower and sweet rocket. Turnip shows a systemic chlorotic mottling with crinkling, leaf distortion, stunting of plants. Cabbage has numerous small, black necrotic rings or spots; cauliflower and broccoli have a diffuse systematic mottling. Horse-radish has blotchy mottling, necrotic rings, flecks, and streaks on petioles and leaf veins. Variegated flowers appear on nasturtium stock, wallflower and sweet rocket; the last may be severely crippled or killed. Transmission is by peach and cabbage aphids. Protect seedlings by spraying or screening seedbeds.

Walnut Brooming Disease

Bunch Disease. Presumably virus.

Watermelon Curly Mottle Bigeminivirus

Occurs in Arizona. Infected *Citrullus lanatus* and *Cucumis melo* var. *cantalupensis* plants showed leaf necrosis, vein banding, curling and stunting symptoms.

Watermelon Mosaic Potyvirus

In Florida and probably other states. Symptoms include mild interveinal chlorosis, stunt, distortion, mottle, consisting of green bands along veins or raised green blisters. Leaf apices often form long narrow, sometimes twisted projections, "shoestrings." A yellow strain of the virus causes more yellow spotting with less shoestring effect.

Watermelon Silver Mottle Tospovirus

On watermelon.

Wheat Streak Mosaic Rymovirus

On wild rice (*Zizania*); foliar streak symptoms with chlorotic areas becoming necrotic with eventual leaf death.

White Clover Mosaic Potexvirus

Known also as Clover Mosaic Virus and Pea Wilt Virus, caused systemic mosaics and chlorotic mottlings on clover plants. Virus is transmitted by contact between plants and by seeds.

White Line Mosaic

A mosaic disease of sweet and dent corn with short chlorotic lines along leaf veinal tissue.

Wild Cucumber Mosaic Tymovirus

Occurs in California and Oregon. Virus caused mild leaf chlorosis on natural hosts: *Marah* sp. and *Echinocistis* sp.

Wineberry Latent Virus

Known as Loganberry Calico Virus induced calico disease-like symptoms on blackberry. Virus is transmitted by mechanical inoculation and by grafting but on many *Rubus* sp. remains symptomless.

Wisteria Mosaic

Diffuse yellowish blotches with scattered green islands; mature leaflets twisted.

Wisteria Vein Mosaic Potyvirus

On wisteria.

Yellow Mottle Begomovirus

On okra.

Zucchini Yellow Mosaic Potyvirus

On cucurbits, melon, squash, pumpkin and watermelon.

Zygocactus Montana X Potexvirus

Serologically related to many potexviruses, caused reddening of pads of infected *Zygocactus truncatus* plants. It was found in the USA but there is not evidence of spread.

WHITE RUSTS

White rusts are all members of a single genus, *Albugo*, in the Oomycetes and are apparently obligate parasites like the true rusts. They form a white blister just underneath the epidermis.

Albugo (Cystopus)

Oomycetes, Peronosporales

Sporangia are borne in chains at apex of a short, clavate, usually unbranched sporangiophore, forming a limited sorus beneath the host epidermis and exposed by its rupture. The mycelium is intercellular except for small, knoblike haustoria. The sporangia dry to a white powder and are disseminated by wind, germinating by swarmspores. Fertilization of a globose oogonium and a clavate antheridium produces a single oospore, also germinating by swarmspores.

Albugo bliti. **White Rust** or **White Blister** on beet, amaranth, globe amaranth, seabeach amaranth, and smooth pigweed. Blisterlike white pustules formed in leaves change to reddish brown when mature. Flowers and stems are dwarfed, distorted. The fungus winters in seed coats. Destroy infected plants and debris at end of season. Change location of plantings.

Albugo candida. **White Rust** of crucifers on arugula, cabbage, chinese cabbage, radish, horse-radish, turnip, watercress, garden cress, peppergrass, salsify, mustard, arabis, sweet alyssum, boerhavia, draba, hesperis, candytuft, stock, wallflower and western wallflower.

Blisters appear on any part of the plant except root. They vary in size and shape and are often confluent in extended patches. There seem to be two types of infection: general or systemic, resulting in stunting of entire plant and formation of pustules on all parts; or local, with direct invasion of single leaves, stems, or flowers. Upper surface of leaves often has yellow areas with white pustules on the underside. The latter are powdery when mature, and the epidermis is ruptured to free chains of sporangia that are carried by wind to moist surfaces. They germinate by 6 to 18 zoospores, swarmspores, which settle down, produce germ tubes, and enter plants through stomata.

Stems have localized or extended swellings, sometimes sharp bends, proliferation from lateral buds giving a bushy growth. Various flower parts are deformed with pronounced distortion of flower pedicels. When these thickened parts die, oospores are formed to survive the winter in crop refuse. The disease flourishes in cool, wet weather; the spores germinate better when slightly chilled.

Control. Remove infected parts of ornamentals as noticed. Clean up all vegetable refuse at end of season and all cruciferous weeds nearby. Spraying is impractical.

Albugo ipomoeae-panduratae. **White Rust**, general on sweetpotato, also on morning-glory, moonflower, *Jacquemontia* and quamoclit. The disease is usually late on sweetpotato, after vines have made their growth, but it is very conspicuous with irregular yellow areas on upper surfaces and white cheesy pustules on lower surface. Oospores wintering in host tissue are liberated by decay in spring. There are no control measures.

Albugo occidentalis. **White Rust** of spinach. After a report from Virginia in 1910, the disease went unrecorded until 1937, when it appeared in epidemic form in Texas; it has since been serious in Oklahoma and Arkansas and has attacked all commercial varieties tested at the University of Wisconsin. The white blisters are small, usually on underside of leaves, sometimes on upper. Infected leaves become chlorotic, then brown; the entire crop may be lost.

Albugo platensis. **White Rust**, on trailing four o'clock, common four o'clock, and boerhavia.

Albugo portulacae. **White Rust** of portulaca. Swollen and deformed branches bear white pustules. Shoots tend to become more erect and spindling.

Albugo tragopogonis. **White Rust** of salsify, also on African daisy, antennaria, artemisia, centaurea, feverfew, matricaria, senecio and sunflower. Light yellow areas appear on leaves. The epidermis, forced into domelike swellings, bursts to show chalky sori of spores. Foliage may die; plants are dwarfed. There is no control.

WILT DISEASES

To wilt means to lose freshness or to become flaccid. Wilting in plants may be temporary, due to too rapid transpiration; or it may be permanent, due to continued loss of water beyond the recovery point. Disease organisms, by reducing or inhibiting water conduction, may cause permanent wilting. Because wilt diseases are systemic, and tied up with the entire vascular system of a plant, they are usually more important, and harder to control, than localized spots or cankers. In many cases the fungus enters the plant from the soil through wounds or root hairs and cannot be controlled by protective spraying. Often, although the fungus is present only near the base of a plant, the first symptom is a flagging or wilting or yellowing of a branch near the top. Many species of *Fusarium* are responsible for important wilts and "yellows." *Verticillium* is a common cause of wilt in maples, other trees, and shrubs, but most important among the wilt pathogens are two species of *Ceratocystis*, one causing oak wilt, the other Dutch elm disease.

Acremonium (Cephalosporium)

► Leaf Spots.

Acremonium diospyri (formerly *Cephalosporium diospyri*). **Persimmon Wilt**, a lethal disease of common persimmon. Wilt appears in scattered localities from North Carolina to Florida and west to Oklahoma and Texas, but most infection is in north central Florida and central Tennessee. Spread is rapid and death quick. First notice of the disease was in Tennessee in 1933. By 1938 only 5% of the persimmons in the infected stand were alive. Topmost branches wilt suddenly, then the rest of the tree, with defoliation and death. The fungus fruits in salmon-colored spore masses in cracks in dead bark of dying trees or under bark of dead rings. Fine, blackish streaks are present in five or six outer rings of trunk, branches, and roots. No control is known.

Cephalosporium diospyri (see *Acremonium diospyri*). **Persimmon Wilt**, a lethal disease of common persimmon.
Cephalosporium sp. **Sunflower wilt**.

Ophiostoma (Ceratocystis)

Ascomycetes, Ophiostomatales

Perithecia enlarged at base, with thin walls, and long slender neck, ascus wall evanescent, ascospores hyaline. Conidial stage may be *Chalara* with endogeneous spores or *Graphium* with external conidia or conidiophores united into a dark stalk (synnema).

Ceratocystis fagacearum (*Chalara quercina, Endoconidiophora fagacearum*). **Oak Wilt**, our most serious disease of oaks, now known in 20 states from Texas and Oklahoma east to Pennsylvania and South Carolina. It has also been reported in Florida. Although apparently present in the Upper Mississippi Valley for many years, the disease did not cause concern, and the fungus was not described until 1943, since when it has become a major threat to our forest economy and to trees in residential areas. All native oak species are susceptible, also chinquapin, chestnut, lithocarpus (and apples in experimental inoculation); but red oaks succumb most rapidly. Scouting for the disease has been done largely by airplane, the discolored foliage being visible up to a half mile.
First symptoms are a slight crinkling and paling of leaves, followed by progressive wilting, bronzing, and browning of leaf blades from margins toward midribs and defoliation progressively downward and inward throughout the tree. Red oaks almost never recover and may be killed within 4 to 8 weeks after symptoms appear. White and burr oaks may persist for some years, with affected branches dying in a staghead effect.
The first internal symptoms are the formation of gums and tyloses in the xylem. After wilting, mycelial mats are formed between the bark and wood, and the bark cracks from the pressure exerted. Perithecia are formed in these mats, which have a sour odor and attract insects. Nitulid beetles, fruit flies, brentids, springtails, bark beetles, and possibly other insects get conidia and ascospores on or in their bodies as they feed, and can inoculate other trees through wounds. We know that ascospores remain viable several months on insects and can be distributed through fecal pellets, but we do not yet know how great a role they play in the spread of oak wilt. Birds have been suspected as carriers but are not yet indicted. Local spread is largely by root grafts,

one tree infecting others within 50 feet and with grafts possible between red and white oaks, not limited to the same species.

Control. In residential areas infected trees should be removed. In forests, felling may wound other trees and spread the disease more than letting the dead tree remain but treated so that it is not infective. Different states handle the problem in different ways. In Pennsylvania, each infected tree is cut, with all other oaks within 50 feet, and ammate crystals are placed on each stump. In North Carolina stumps and felled trees are thoroughly sprayed. In West Virginia the trees are left standing, but a deep girdle into the heartwood dries out the tree so that mycelial mats and spores do not form.

Ceratocystis (Ceratostomella) ulmi (**Graphium ulmi**) (see *Ophiostoma ulmi* and *O. novo-ulmi*). **Dutch Elm Disease**, on American, Sibirian, Slippery and European elms in 31 states, Maine to North Carolina and west to Oklahoma, and on cedar.

Ophiostoma ulmi and **O. novo-ulmi** (formerly *Ceratocystis* (*Ceratostomella*) *ulmi* (*Graphium ulmi*)). **Dutch Elm Disease**, on American, Sibirian, Slippery and European elms in 31 states, Maine to North Carolina and west to Oklahoma, and on cedar. This fatal disease is not really of Dutch origin but is so named because it was first investigated in Holland. It was noticed in Europe about 1918, first in France, then in Belgium and Holland. It spread throughout central and southern Europe, then into England and Wales. In many places it virtually exterminated the elms, including those on the famous avenues at Versailles. It is suspected that the fungus came to Europe from Asia during World War I.

Dutch elm disease was discovered in Ohio in 1930 and in New Jersey in 1933. It has spread north through New England and has become very serious in the Midwest. In 1948, the disease was found in Denver, Colorado, and in 1976 in California. It is now fairly widespread in reports of its occurrence in the United States. The spread of the fungus is linked with the presence of the large and small European bark beetles, *Scolytus scolytus* and *S. multistriatus*. Only the latter is established in this country, having arrived in Boston about 1919. Patient detective work established the fact that the fungus came here in elm burl logs imported for furniture veneer. After one such infected elm burl was found in Baltimore in 1934, months of scouting went on in the vicinity of ports of entry, railroad distributing yards, and veneer plants. Such backtracking showed the infected material had come in at four ports of entry and had been carried by 16 railroads over 13,000 miles in 21 states. From this source the disease got its start in at least 13 areas in 7 states.

Elm nursery stock is, of course, quarantined, and elm burls are embargoed; but who who would have believed that dishes could have anything to do with killing our elms? Dishes have to be crated, however, and several times since 1933 English dishes crated with elm wood carrying bark beetles and *Ceratocystis* have been intercepted. All American and European elms are susceptible. Asiatic elms, *Ulmus parvifolia* and *U. pumila*, are resistant. A seedling elm, named Christine Buisman for its Netherlands' discoverer, is highly resistant, though not immune, and is now available. Other promising seedlings have been tested by the U.S. Department of Agriculture.

Symptoms are apparent from the latter part of May until late fall. The acute form of the disease is characterized by sudden and severe wilting. First the young leaves, then all leaves wilt and wither, sometimes so rapidly that they dry, curl, and fall while still green, before they can turn the usual brown of dead leaves. Sometimes terminal twigs are curled into a shepherd's crook. Chronic disease symptoms are gradual, often taking all summer for complete defoliation. In many cases individual branches or "flags" appear, the yellowed leaves conspicuous against the rest of the tree; but sometimes all leaves gradually turn yellow. In another type of chronic disease, trees leaf out late in spring, with sparse chlorotic foliage and a staghead appearance.

When an affected twig is cut across, the vessels or water-conducting tubes show dark brown or black, being clogged with bladderlike tyloses and brown gummy substances (see Fig. 3.62). The production of these substances is thought to be stimulated by a toxin secreted by the fungus and carried in the sapstream. Symptoms are not dependent on the physical presence of fungal hyphae in all parts of the tree. The fungus lives in the sapwood, fruiting in cracks between wood and loosened bark and in bark beetle galleries under the bark. This fruiting is of the anamorph state, spores being produced in structures called coremia. These are black stalks about 1 mm high with enlarged heads bearing vast numbers of minute, pear-shaped spores embedded in a translucent drop of sticky liquid. Spores in the vessels increase in a yeastlike manner. The perithecial stage, not found in nature, has been produced in culture by crossing plus and minus strains of the fungus.

Although the smaller European elm bark beetle is chiefly responsible for spread of the pathogen, at times the native elm bark beetle, *Hylurgopinus rufipes*, is the agent. When the adult beetles emerge from under the bark of dead or dying trees, they bring along sticky spores on their bodies and deposit them as they feed in the crotches of young twigs or leaf axils of near-

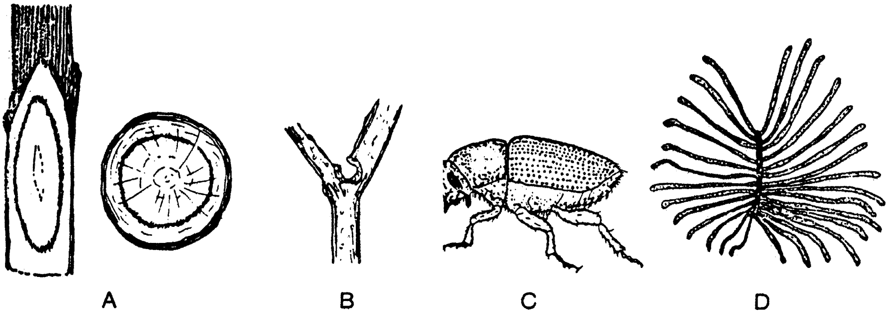


Figure 3.62 Dutch Elm Disease. **A** branch cut to show discoloration of wood; **B** wound in twig crotch due to beetle feeding; **C** bark-beetle carrier of the fungus; **D** egg and larval galleries of the beetle engraved on sapwood

by healthy trees. Although the beetles feed on healthy wood, usually within 200 feet of their original tree, they breed only on weakened or dying wood and may fly some distance for it. The European female tunnels out a brood gallery 1 or 2 inches long in the wood, and when the larvae hatch, they tunnel at right angles across the wood (Fig. 3.62). There is a second brood in August and September, but the overwintering one, emerging in May, is most to be feared. Because the disease often follows traffic routes, automobiles probably account for a good deal of long-distance spread. So far as we know, the only other natural means of infection is by root grafts, made when trees are planted so close together that their roots touch. This is another argument for diversified planting, rather than streets closely lined with but one type of tree.

Control. In the first few frantic years an enormous amount of money (more than $26 million) was spent on trying to eradicate the disease by removing and burning diseased trees; and while this was undoubtedly helpful, it did not stop the spread of wilt. The Federal government has now left the control of Dutch elm disease up to the communities and is restricting its efforts to research. Many towns have taken a laissez-faire attitude, thinking that our elms are doomed anyway, so why waste money? Other, more enlightened communities have proved that a sustained control program keeps the disease down to a negligible 1 or 2%, or less, and that the cost is far, far less than that of continuous removal of dead trees.

The Midwestern Chapter of the National Shade Tree Conference, in its *Guide for Community-Wide Control of Dutch Elm Disease*, suggests:

1. Survey of the total elm tree population to be protected.

2. Symptom scouting for detection of diseased trees and sanitation scouting for badly weakened elms and wood piles containing elm wood.
3. Destruction of known sources of elm wood actually or potentially hazardous for spread of disease. Elm wood piles should be destroyed completely, or each log stripped of bark and the bark destroyed. Diseased trees should be burned, on site if possible, or thoroughly sprayed. Wood chips from diseased elms may still carry the fungus; material should be burned, not used for mulches.
4. Spraying of healthy trees to prevent infection.
5. Maintenance of elms in healthy condition to prevent invasions of bark beetles. This includes proper watering and fertilizing, spraying to control summer foliage pests if necessary.

A single annual DORMANT SPRAY is now considered sufficient to protect healthy elms from bark beetles if enough material is used and complete coverage is obtained. This spray was originally a very heavy dosage of DDT, which caused some bird mortality and other environmental problems. Some communities, of which Greenwich, Connecticut is a good example, figure that they cannot afford not to spray, for it costs less to spray for control than to remove a dead tree. Where dormant spraying and sanitation have been combined consistently, the annual loss from Dutch elm disease has been kept to 1% or less.

Chemotherapy, injection of chemicals that will inactivate the fungus, has been a promising line of research for many years. A parasitic European wasp is now being bred at several laboratories for release against the bark beetles. To have elms in our future we must keep on planting them. Some forms, such as the Christine Buisman and Groeneveld elms, are quite resistant although not immune. Chinese and Siberian elms are resistant.

Dothiorella

► Cankers.

Dothiorella ulmi. **Dothiorella or Cephalosporium Wilt** of elms. **Dieback**, rather common on American elms, occasional on slippery and Siberian elms in central and eastern states. The names are confusing. In culture the fungus develops spores as in *Cephalosporium*, but in nature *Dothiorella*-type pycnidia are developed on bark of killed twigs. The fungus has also been classified as *Deuterophoma*. Spores are extruded in a sticky mass and are disseminated by wind, rain, possibly insects. Infection is through insect or other wounds on foliage. The mycelium proceeds from leaf petioles into wood, where it is confined to the vessels. The foliage wilts and yellows; there are gradual dying back of the crown and a brownish discoloration in outer rings of the wood. Without laboratory diagnosis the disease cannot be positively separated from Dutch elm disease, but the elliptical cankers on the stems, with small black specks of pycnidia, provide one diagnostic symptom. Older trees die 3 to several years after first symptoms; nursery trees, in 1 or 2 years. Some trees recover, and some remain infected for many years without showing much effect.

Control. Prune out infected branches a foot or more below the lowest point of discoloration. Promote vigor by feeding, watering, aerating soil. The inclusion of a fungicide in sprays for elm-leaf beetles or cankerworms might be helpful.

Fusarium

► Rots.

Fusarium annuum (*F. solani*). **Fusarium Wilt** of chili pepper. Underground stems are dry, brown, but the roots soft and water-soaked; plants wilt and die rapidly. Spores are spread in irrigation water and with wind-blown particles of soil. Avoid heavy, poorly drained soils.

Fusarium foetens. **Wilt** on begonia.

Fusarium oxysporum. **Wilt** on pyracantha and basil. **Blight and Wilt** on purple coneflower (*Echinacea*).

Fusarium oxysporum f. sp. **apii**. **Celery Wilt**, **Yellows**, general in northern celery districts. There are three strains of the fungus, all causing stunting, vascular discoloration, crown and root rot, but one form causes the entire plant to turn yellow at high temperatures, producing brittle stalks with a bitter taste. Another strain causes downward curling of young heart leaves, and the third produces no above-ground symptoms except stunting. The fungus persists indefinitely in soil. Golden, self-blanching varieties are more susceptible. Grow green petiole celery or somewhat resistant Michigan Golden, Cornell 19, Tall Golden Plume, Golden Pascal or Emerson Pascal.

Fusarium oxysporum f. sp. **asparagi**. **Fusarium Wilt** of asparagus, a major factor in asparagus decline in California, found in most plantings. The fungus lives in soil and may be distributed on seed.

Fusarium oxysporum f. sp. **barbati**. **Fusarium Wilt** of sweet william. New growth is yellowed; plants are stunted; leaves point downward and are tinged with tan as they die. Roots and lower stem are discolored brown. Plant in new or sterilized soil.

Fusarium oxysporum f. sp. **batatas**. ► Rots.

Fusarium oxysporum f. sp. **betae**. **Fusarium Yellows** on sugar beet.

Fusarium oxysporum f. sp. **callistephi**. **Aster Wilt**, one of the most serious diseases of China aster, unless resistant seed is used. Plants wilt, wither, and die at any age from seedlings to full bloom. Older plants are often stunted, with a one-sided development and a brown discoloration of the vascular system. Sometimes all lower leaves are wilted, with blackening at base of stem, often with a pink spore mass at ground level. Plants in full bloom may suddenly droop their heads. Such symptoms are in contrast to the mycoplasma-like disease, aster yellows, where the plant remains upright, although stunted and yellow. The fungus is seed-borne and persists in the soil many years.

Control. Sterilize soil for seedbeds. Some seedsmen provide seed of wilt-resistant varieties, but maintaining resistance means continuous selection from asters grown on heavily infested soil under conditions highly favorable for infection, and this is an expensive process.

Fusarium oxysporum f. sp. **cattleyae**. **Wilt** of cattleya orchids. The fungus was isolated from a private collection in Ohio. Leaves wilted, roots abscised and decayed; flowers fewer, smaller, short-lived.

Fusarium oxysporum f. sp. **chrysanthemi**. **Fusarium Wilt** on chrysanthemums.

Fusarium oxysporum f. sp. **conglutinans**. **Cabbage Yellows**, **Fusarium Wilt**, general on cabbage and other crucifiers, probably the most destructive disease of such hosts in the Midwest, perhaps other sections. It is serious on cabbage, kohlrabi, and collards. Brussels sprouts, cauliflower and broccoli are moderately susceptible in hot dry seasons. The fungus, which can live many years in the soil, enters through the roots, usually right after transplanting or at the first hot weather, with potassium deficiency as well as heat thought to favor infection. The fungus progresses upward in the xylem, not invading other elements until the plant dies.

The most striking symptom is the dull yellow to greenish color of the foliage, together with a warping or curling of basal leaves. Leaves are killed and shed from the base up; the woody tissue in the stem is brown, with a water-soaked appearance. The fungus is spread by soil clinging to farm implements, drainage, water, wind, animals and infected seedlings. Once the disease is established, general sanitation and crop rotation are of little help against a fungus that can survive so long without a susceptible host.

Control. Once soil is infested resistant varieties offer the only hope. Many have been developed, including Jersey Queen, Marion Market, Wisconsin Golden Acre, Resistant Detroit, resistant strains of Early Jersey Wakefield, Charleston Wakefield, Globe, Wisconsin All Season and Wisconsin Hollander.

Fusarium oxysporum f. sp. **cucumerinum**. **Cucumber Wilt**. A newly recognized form of *Fusarium* highly pathogenic to cucumber and muskmelon in Florida, only slightly pathogenic to watermelon.

Fusarium oxysporum f. sp. **cyclaminis**. **Fusarium Wilt** on cyclamen.

Fusarium oxysporum f. sp. **cubense**. **Wilt** of banana.

Fusarium oxysporum f. sp. **dianthi**. **Carnation Fusarium Wilt**, **Yellows**, **Branch Rot**, general. The first symptom is a slow withering of shoots, often accompanied by change of color from normal deep green to lighter green to pale straw yellow. Plants appear wilted, especially during the warmer part of the day. Only one side of the plant may be affected, resulting in distortion and tendency to curl. If the stem is split, a brownish streak is seen in the vascular system. There may be a dry, shreddy rot of affected wood and cortex. Plants may be infected at any age, but succumb faster if attacked when young. This species of *Fusarium* does not rot roots; see *F. roseum* under Rots for the form causing stem and root rot on carnation.

Control. Sterilize greenhouse soil and benches; take cuttings from healthy mother block; avoid overwatering. Drenching newly flatted or benched plants has reduced the number of wilted plants but does not replace steaming or otherwise sterilizing soil.

Fusarium oxysporum f. sp. **erythroxyli**. **Wilt** of *Erythroxylum*.

Fusarium oxysporum f. sp. **gladioli**. ►Rots.

Fusarium oxysporum f. sp. **hebae**. **Fusarium Wilt** of *Hebe buxifolia*, and veronica. Reported as killing nursery plants in California.

Fusarium oxysporum f. sp. **lactucum**. **Wilt** of lettuce.

Fusarium oxysporum f. sp. **lycopersici**. **Fusarium Wilt** of tomato, general, in many sections the most damaging tomato disease in field and greenhouse. Chief losses are in states where air temperatures are rather high during most of the season, susceptible varieties dying or producing little fruit. Losses go up to 30,000 tons of canning tomatoes, or 10 to 35% of the crop in many states.

In seedlings there is downward curvature of the oldest leaves followed by wilting and death. In older plants the disease is most evident as fruit begins to mature, lower leaves turning yellow, first on one side of the stem or leaflets on one side of the petiole. One shoot may be killed before the rest of the plant shows symptoms.

The fungus enters through roots and grows into the stem, where it produces the toxic substances causing wilting and eventual death. The vascular system in the stem shows a dark brown discoloration. In severe infections the fungus grows into fruit and seeds, but such fruits usually drop, and seed is not used. Almost all original infection comes from the soil, the *Fusarium* operating best in light sandy soils and at temperatures between 80° and 90° F, but the disease is spread widely in transplants. It is encouraged by low potassium and high nitrogen nutrients.

Control. Start seedlings in clean soil; do not grow in the same land more than once in 4 years. The use of resistant varieties is the chief means of control. Marglobe, Pritchard and Rutgers are moderately resistant, but infestation by nematodes may predispose even these to wilt. Pan America, Southland, Homestead and Jefferson are more highly resistant. Treating soil with nematicides may reduce incidence of wilt even though the wilt pathogen is not killed.

Fusarium oxysporum f. sp. **melonis**. **Muskmelon Fusarium Wilt**, similar to that of watermelon, important in Minnesota, New York, New Jersey and Maryland. Seeds rot in soil; seedlings damp-off; vines wilt. Fungus persists in soil and is carried internally in seed. Varieties Golden Gopher and Iroquois are quite resistant.

Fusarium oxysporum f. sp. **niveum**. **Watermelon Wilt**, general on watermelon, also on citron. The fungus is transported in and on seed and persists in soil 15 to 18 years. It rots seeds or seedlings, causes wilting of plant, sometimes with cottony mycelium on surface of dying vines. Resistant varieties include Improved Kleckley Sweet and Klondike.

Fusarium oxysporum f. sp. **perniciosum**. **Mimosa Wilt** on mimosa from New Jersey and Maryland to Florida. This extremely pernicious wilt started about 1930 at Tryon, North Carolina, and mimosas have wilted and died at a rapid rate ever since. The wilt appeared in one city block at Morgantown, North Carolina in 1943, and by 1947 trees were dead and dying on 232 blocks.

The first external symptom is a wilting and yellowing of leaves on some of the branches, causing foliage to hang down, then die and drop. Death of the tree follows from a month to a year after first infection. The trunk has a brown ring of discolored sapwood, usually in the current annual ring, and the color may extend out into the branches. The xylem is plugged with brown gummy substances. Small branches may have a one-sided wilting with the bark flattened over collapsing tissue. The disease has been spreading in Maryland since 1947, in Florida since 1952.

As with other *Fusaria*, this is a soil fungus entering through the roots, and eradication of diseased trees has no effect on spread of the wilt. Nematodes, by their wounds, may increase the incidence of wilt. Out of a great many seedlings grown from seed collected from Maryland to Louisiana, inoculated several times with the fungus and planted in infested soil, some have remained mostly disease-free. These have been propagated by the U.S. Department of Agriculture. Released for commercial sale are Charlotte and Tryon.

Fusarium oxysporum f. sp. **pisi**. **Pea Wilt**, caused by race 1 of this pathogen and **Near Wilt**, caused by race 2. Race 1, confined to pea, produces stunted plants, pale yellow green, with leaves curled downward, stem thickened and brittle near the ground. Plants wilt and die prematurely. The disease may cause more or less circular bare spots in the field, enlarging each year if peas are planted continuously, encouraged by high soil temperature. Some commercial pea varieties are resistant to race 1 but not to race 2. Delwiche Commando was the first variety introduced resistant to both races.

Fusarium oxysporum f. sp. **raphani**. **Radish Wilt**. Young plants turn yellow and die; others are stunted, with discoloration of roots.

Fusarium oxysporum f. sp. **spinaciae**. **Fusarium Wilt** of spinach. Plants are pale; leaves roll inward, gradually die. The wilt is serious in Texas and Virginia. One form of the mosaic-resistant Savoy spinach is also resistant to wilt.

Fusarium oxysporum f. sp. **tracheiphilum**. **Wilt** of cowpea.

Fusarium solani f. sp. **pisi**. **Wilt** of chick-pea.

Hendersonula

Deuteromycetes, Coelomycetes

Pycnidia dark, separate; spores dark with several cells.

Hendersonula toruloidea. **Branch Wilt** of walnut. **Canker**, destructive to Persian walnuts but associated with sunburn of affected branches. The fungus is a wound parasite.

Phialophora

► Rots.

Phialophora gregata. **Wilt** of chick-pea.

Phomopsis

► Blights.

Phomopsis sp. **Wilt** on ice plant.

Phytophthora

► Blights.

Phytophthora cactorum. **Wilt** of blue laceflower and baby's breath.
Phytophthora cinnamomi. **Rhododendron Wilt**. A wilt of young stock, grafted plants 2 to 3 years old, seldom on older shrubs, most severe on *Rhododendron ponticum*. The foliage is first dull yellow, then permanently wilted, roots are decayed; stems are brown at soil level and below. Remove infected stock from frames immediately; avoid excessive irrigation; keep soil acidity at pH 4.0 to 4.5; provide shade and mulch for young plants. This pathogen also causes wilt of Japanese umbrella tree.
See under Rots for this fungus at work on many other plants.

Pythium

► Rots.

Pythium myriotylum. **Wilt** on peanut.
Pythium tracheiphilum. **Wilt** on lettuce and also leaf blight.
Pythium aphanidermatum. **Wilt** of *Nicotiana*.

Rhizoctonia

► Blights.

Rhizoctonia solani. **Wilt** of watermelon.

Sclerotinia

► Blights.

Sclerotinia minor. **Wilt** of lupine and wild garlic.

Verticillium

Deuteromycetes, Coelomycetes

Conidia one-celled, hyaline, globose to ellipsoid, formed at tips of whorled branches and separating readily from tips.

Verticillium albo-atrum. **Verticillium Wilt**, **Maple Wilt** of many ornamental trees, shrubs, fruits, flowers and vegetables. The fungus was first isolated from potatoes in Germany in 1870 but apparently was present in California as early as 1850. It attacks nearly 300 cultivated plants of widely diverse types and may persist as a saprophyte in the soil 15 years or more.

Of the ornamental tree hosts silver maples are most susceptible, then sugar and red maples, elms, with occasional reports on ailanthus, alfalfa, aspen, ash, boxelder, beech, black locust, camphor-tree, carob, catalpa, Chinaberry, cucumber, deerbrush, dogwood, goldenrain, horse-chestnut, India hawthorn, redbud, linden, magnolia, oak, osage-orange, olive, pistachio, persimmon, periwinkle, Russian olive, sassafras, strawberry, smoke-tree, tulip-tree, walnut, mango, sunflower and hickory. Maples may wilt suddenly in midsummer, often a large branch or one side of the tree drying and dying while the other side stays fresh. The sapwood of the infected side has greenish streaks, and sometimes slime flux develops on the bark. The disease can be chronic, progressing slowly for several seasons, or acute, affecting the entire tree in a few weeks. In elms the leaves may be smaller than normal, with a drooping flaccidity in hot hours of the day. Later there is a slight yellowing, deepening until the foliage is a striking lemon yellow. Defoliation starts at time of first yellowing, and quite often branchlets drop as well as leaves. Sapwood discoloration is brown, and the disease cannot be told positively from Dutch elm disease without laboratory cultures. Tyloses and gums are formed in the wood as with other toxin-producing fungi. The fungus always progresses upward through the xylem vessels so there is little danger of downward infection of the main trunk from pruning operations. Progress is slowed by adequate moisture and by high nitrogen fertilizers, ammonium sulfate being particularly helpful.

Verticillium wilt is also a problem on rose understock. Ragged Robin, Odorata, and Multiflora are very susceptible, Dr. Huey less susceptible, and Manetti resistant.

In fruit trees the wilt is often known as black heart or verticillosis. It is common in apricots, less so in almonds and peaches; branches may drop their leaves and die. Also susceptible are sweet and sour cherry, avocado, plum and prune.

On bush fruits – raspberry, blackberry, dewberry and youngberry – the disease is commonly known as blue stem. The symptoms appear late in the season, leaves turning pale, cane tips bending downward, canes taking on a bluish color, lower leaves wilting and drying. Death is often delayed until the season after first infection. Black raspberries are more susceptible than red. The disease is sometime serious on strawberries, especially in California, but cannot always be separated from root rots. Plants may collapse in large areas at the beginning of hot weather.

Verticillium wilt is very destructive to mint in Michigan and Indiana, also reported, though not so serious in Oregon and Washington. Infected plants

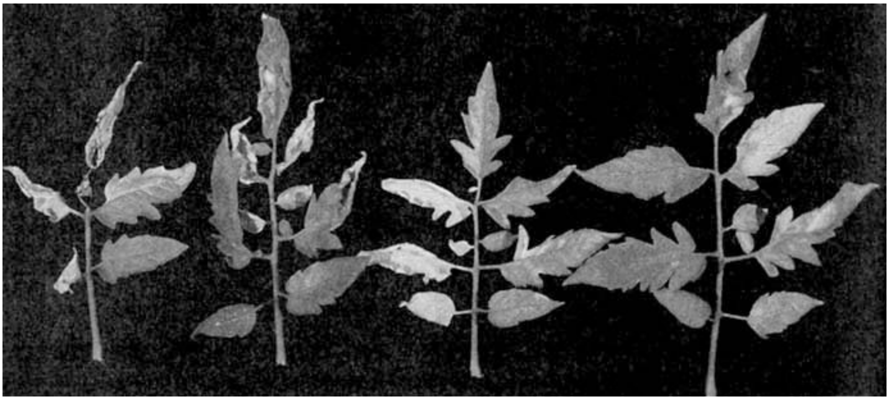


Figure 3.63 Verticillium Wilt on Tomato

are stunted, defoliated, and killed; yield of oil is greatly reduced. The fungus attacks all species of mint, but peppermint is most susceptible. There are some resistant hybrids. Deep plowing, inverting the soil, has reduced the amount of wilt.

Verticillium is especially damaging to tomatoes in Utah and California. First symptoms are yellowing of older leaves and wilting of tips during the day;

Figure 3.64 Verticillium Wilt on Potato

Figure 3.65 Verticillium Wilt on Snapdragon

later, margins of all leaves curl upward, then leaves drop (see Fig. 3.63). Plants are stunted; fruit is small. Moderately resistant varieties Riverside and Essar have been developed for California. Symptoms on potatoes are rather indefinite, but often there is yellowing of lower leaves, shortening of internodes, and rosetting of the top (see Fig. 3.64). Resistant varieties may be symptomless hosts. Verticillium wilt is common on eggplant and okra, rather rare on pepper. It occurs on Chinese yard-long bean, rhubarb and New Zealand spinach.

On herbaceous perennials in eastern gardens I find Verticillium wilt common on aconite and chrysanthemum, with leaves turning dark brown and hanging down along the stem. When the stem is cut across near the base, a circle of black dots indicates the fungus in the vessels. Such plants seldom die immediately but flower poorly and gradually peter out. Wilt was serious on greenhouse chrysanthemums until a wholesale commercial concern started to provide healthy propagating stock from cultured cuttings. Other ornamental hosts include abutilon, aralia, barberry, begonia, China aster, carnation, dahlia, fremontia, geranium, marguerite, peony, poppy, snapdragon (see Fig. 3.65), stock and viburnum.

Control. Sometimes it is possible to prune out an infected maple and still save the tree, but often the dying tree must be taken out. Neither maple nor elm should be replanted in the same spot. Do not transfer plants from areas where wilt has appeared. Do not set raspberries following potatoes or tomatoes; do not use tomatoes after eggplant or potatoes without a long rotation. Proper fertilization and adequate watering may help trees to recover from wilt.

Verticillum dahliae is considered by some a synonym of *V. albo-atrum* and by others as a distinct species; reported as causing wilt of dahlias, mint, marigold, ice plant, barley, wheat, oat, potato, Leucospermum, impatiens, giant hyssop, globe artichoke, ash, cabbage, Cineraria and Echinacea, and other plants. This form has microsclerotia and grows on agar at slightly higher temperatures.

Verticillium fungicola. **Dry Bubble** of oyster mushroom. Infection of sporophores at pin or button stage cause development of typical dry bubbles; mature sporophores show cracking and curling of tissues, and depressed, brown, necrotic areas.

WITCHWEED

A parasitic weed, *Striga asiatica*, new to the western hemisphere, was reported from North Carolina in 1956 and later from South Carolina, although apparently it was first seen in the latter state in 1951 following construction of a power line across a farm. The plant is an obligate root parasite of corn and crabgrass, perhaps other plants. It is 2 to 15 inches high, foliage varying from dark to light green, with linear leaves curving downward, tubular flowers with two-lipped corolla, cardinal red on the upper surface with a yellow eye, straw yellow on the lower surface. The numerous brown seeds are very minute.

Witchweed is reported from other countries on 63 plant species, 56 of them members of the Gramineae (grains and grasses). Tests in the United States with 77 non-gramineous hosts found none parasitized by witchweed, but 45 species of our grasses and grains are susceptible to this new pest. To help in eradication, report suspicious weeds immediately to your county agent or extension pathologist.